THE EXPLOSIVES ENGINEER

FORE-RUNNER OF PROGRESS IN
MINING-QUARRYING & CONSTRUCTION

SEPTEMBER · OCTOBER · 1961

VOLUME 39 · NUMBER 5

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Forerunner of Progress in Mining, Quarrying, Construction

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Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

Some idea of the scope and range of the research activities of the Armed Forces can be gained from our lead article, "Tunneling in Glacial Till," which starts on page 135.

This project was conducted by the U. S. Army Snow, Ice, and Permafrost Research Establishment to study methods of excavating permafrost, to determine the characteristics of the glacial till, and to investigate the feasibility of making underground openings in the permafrost. The ultimate use of such underground openings would be for the protection of personnel and supplies from the severe Arctic weather conditions.

The two authors are well qualified to present this enlightening article. John F. Abel, Jr., a mining engineer, spent four summers in Greenland on this project and was project leader during 1959. Robert W. Jennings, Jr., also a mining engineer, was on the project two summers as shift boss and mining supervisor.

* * *

With the trend toward building larger merchant ships as well as gigantic naval craft, the Panama Canal began to feel the pinch, literally as well as figuratively, of these monster ships.

The surveys made as recently as a decade ago which showed the Canal adequate to handle anticipated shipping have been rendered obsolete by two factors—the introduction of superships and the great increase in shipping because of expanding international trade. Something had to be done and done quickly to prevent this vital link between the Atlantic and Pacific Oceans from becoming a bottleneck. Two studies were made—one to solve the immediate problem and the second made from the long-range viewpoint. The first study showed that several things had to be done to increase the capacity of the Canal: increase the efficiency of the locks, light Gaillard Cut to facilitate night navigation, and widen the cut.

Charles McG. Brandl, project engineer of the Panama Canal Company, describes the procedures used in widening and deepening the canal under the Paraiso-Cucaracha Reach Widening contract, which was awarded to the firm of Merritt-Chapman & Scott Corp. His article, which features the drilling, blasting, and excavating phases of this contract, starts on page 143.

* * *

Down in El Paso, which is within a stone's throw of Mexico, there are Mexicans who are throwing stones, and it is happening daily in the quarry of Hugh McMillan, Inc.

This unusual situation is not a manifestation of any international animosity but merely employes of Mexican contractors hand-picking choice stone for boundary walls, fences, and other building uses. These Mexicans come daily from neighboring Ciudad Juarez to the McMillan Quarry, and the results of their craftsmanship combined with the colorful stone can be seen in many exclusive residential areas of El Paso.

William K. Hays has an interesting and informative article that describes not only this hand work, but also normal mechanical procedures of this operation. His article starts on page 149.

* * *

How to remove a tough concrete curbing in the middle of a heavily traveled highway with a minimum of interference to traffic—that was the problem confronting Harry T. Campbell Sons' Corporation which had the contract to channelize Eastern Boulevard in Baltimore, Maryland.

The problem was solved by the skillful use of small charges of explosives under the expert guidance of Burnbrae, Inc., demolition contractors of Baltimore. The story of how 300 ft. of this curbing was removed by explosives in six working hours is told by William F. Hallstead. Please turn to page 154.

EDITORIAL STAFF: JAMES J. O'NEILL, *Editor;* THOMAS E. MILLER, *Associate Editor;* GERTRUDE A. DONNELLY, *Associate Editor;* EDWARD L. GRANT, *Art Editor;* HOWARD B. DICKSON, *Production Manager;* A. J. ACKERMAN, *Advertising Manager;* MONTGOMERY R. BUDD, *Director.*

THE EXPLOSIVES ENGINEER, 670 HERCULES TOWER, WILMINGTON, DELAWARE. PRINTED IN UNITED STATES OF AMERICA.

PUBLISHED BY *HERCULES POWDER COMPANY*

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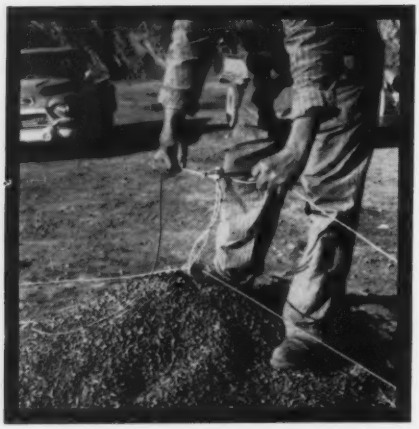
VOL. 39 NO. 5 SEPTEMBER-OCTOBER, 1961



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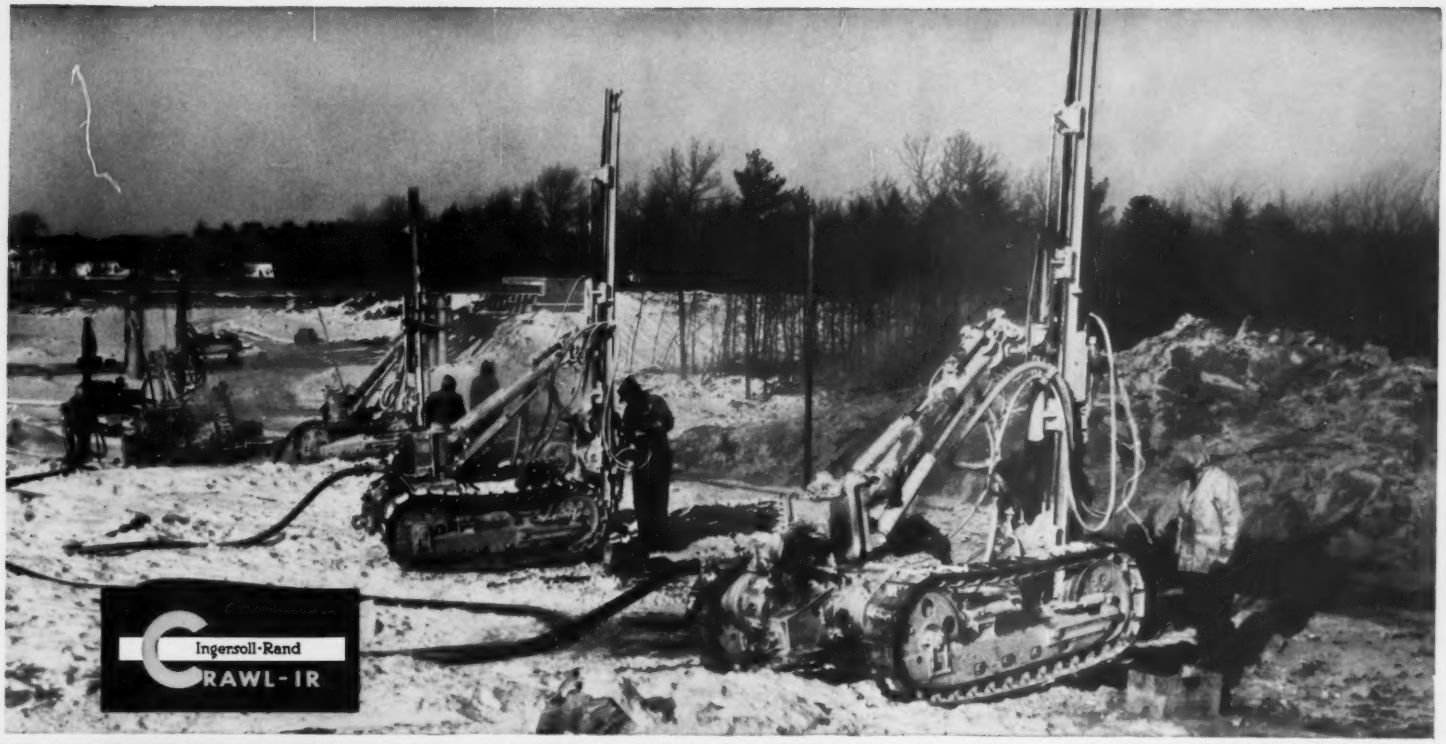

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On the job shown above, five CRAWL-IR drills powered by three 900-cfm Gyro-Flo portables are removing rock for a new Interstate Highway in Massachusetts. Excellent breakage is obtained with a 9′ x 7′ pattern for holes from 10′ to 25′ deep, and 9′ x 8′ for holes from 25′ to 40′ deep.

The rugged, *fully mechanized* CRAWL-IR packs more power and gives more coverage at a single setup than any other machine in its class. And the smooth-running Gyro-Flo compressors stay on the job month after month with practically no attention or maintenance—start fast in the coldest weather, deliver dependable power all year 'round.

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CHRISTIAN F. BEUKEMA

Christian F. Beukema

PRESIDENT

OLIVER IRON MINING DIVISION

UNITED STATES STEEL CORPORATION

A Biography

CHRISTIAN F. BEUKEMA, president of the Oliver Iron Mining Division of United States Steel Corporation, is a man dedicated to his job. This dedication has given him the singleness of purpose necessary to help him carry the heavy burdens of his position.

Mr. Beukema's early years were an excellent preparation for the tough job he now holds. Throughout high school in Grand Haven, Michigan, and Michigan State University, where he graduated in 1940 with a C.E. degree, he must have put in almost as much time earning his tuition as he did studying. In Grand Haven, his jobs included work in a piano factory, in a brass foundry, and with the Ottawa County Road Commission as a road worker, "scythe man," and rod man. He worked his way through college stoking a furnace, washing dishes, waiting on table, radio announcing, and surveying. While always active in campus activities, he did not try his luck in politics until he unsuccessfully bucked the fraternity bloc as the independent candidate for senior class president.

After college, Chris began immediately with U. S. Steel in maintenance and construction engineering at the Calcite Plant of Michigan Limestone at Rogers City.

In 1941, he entered the Armed Forces and served overseas with the Sixth Army Group Headquarters and with Headquarters, U. S. Forces, European Theater, and was involved mainly with troop deployment. He was mustered out with the rank of major. In 1949, Chris was transferred to Pittsburgh as special assistant to Steel's vice president—raw materials, and made director of planning in the raw materials division in 1951. He returned to Michigan Limestone in 1953 as general manager of operations, was appointed vice president in 1954, and president in 1955. He was appointed president of Oliver on January 1, 1960.

Even before coming to Oliver he realized that the tax problem would be the biggest job he faced and he has dedicated himself to its solution. In discussing Minnesota's iron ore industry, Mr. Beukema has said: "There has been a substantial change in the position of Minnesota's iron ores in recent years. Today, iron ores of many states and nations compete with Minnesota ores, while only a few years ago Minnesota ores were almost the only source of this vital raw material for the American iron and steel industry.

"Minnesota's position in the world iron ore market can be retained only by keeping the quality of its ores competitive and maintaining costs that compare favorably with the cost of iron ore produced in other states in this country and throughout the world. This is why Minnesota's state and local taxation of iron ore should be reviewed and understood by every Minnesotan if the iron ore industry is to remain healthy and capable of providing jobs, payrolls, and opportunities for Minnesota citizens."

Mr. Beukema has set his energies to the task of creating a better-informed public opinion toward the Minnesota iron ore industry. In his less than two years as president of Oliver he has accomplished much in bringing the realities of the state's ore tax problem to the people.

Because of the demands of his job, hobbies for Chris are almost, but not quite, out. He plays about five rounds of golf a season if he is lucky. Recently he bought an outboard motor boat which he and his sons use to water ski on some of the lakes near Duluth. His real hobby, however, is taking colored three-dimension pictures; he has coupled meetings of the American Mining Congress with picture taking in Grand Canyon, Bryce, Zion, Cedar Breaks, and Rocky Mountain National Parks. He does not project his pictures in stereo projection because of the technical difficulties involved, but he projects single frames for his house guests, and then offers them a stereo viewer if they wish to see the pictures in depth.

Mr. Beukema is active in community affairs wherever his job takes him. He is a member of the boards of the Duluth Chamber of Commerce; St. Lukes Hospital of Duluth; Duluth Junior Achievement; and the Upper Mid-west Research and Development Council, a joint area study which includes the whole Ninth Federal Reserve District, partially financed by a grant from the Ford Foundation. He is also a trustee of Carleton College, a vice president and director of the American Iron Ore Association, director of the American Mining Congress, chairman of the Michigan State University Development Fund, and a past chairman of the Michigan State Alumni Advisory Council.

In 1941, Mr. Beukema married Elizabeth Robertson of Highland Park, Michigan. They have two sons: John, fourteen, and Bob, twelve. The family lives at 455 Hawthorne Road, Duluth.

Editorial

Suit Charges Company Left Dynamite Cap in Load of Coal
BOONVILLE, Ind.—(Special)—A Boonville man has filed a $45,000 suit against the Hnito Uoin Uoth-
Suit Over Blasting Caps Injuries To Boys On Trial
West Newbury Boys Get $8,250 In Settled Suit
SALEM—A out-of court, settlement for $8,250 was reached yesterday in
Dynamite Cap Suit Settled For $1,000
Polk Boy Who Lost Eye In Blast Sues For $500,000
BARTOW, Oct. 26. (Special)—A 13-year-old Lakeland boy, who was blinded in one eye by the explosion of a blasting cap five months ago, sued Hnito Pui tin Rurlfomnuts Thiitten in Polk County Circuit Court today for $500,000.

HOW TO COMBAT THIS

The Institute of Makers of Explosives has conducted a campaign for many years to prevent blasting cap accidents to children. THE EXPLOSIVES ENGINEER feels that this is one of the finest efforts of the industry, one in which we have always cooperated to help in the reduction of these pitiful accidents.

The work of the I.M.E. has been devoted mainly to carrying a warning to the children. Unaware of the great power of these explosives, the children do not know that they cannot play with the bright-colored cylinders without courting great danger.

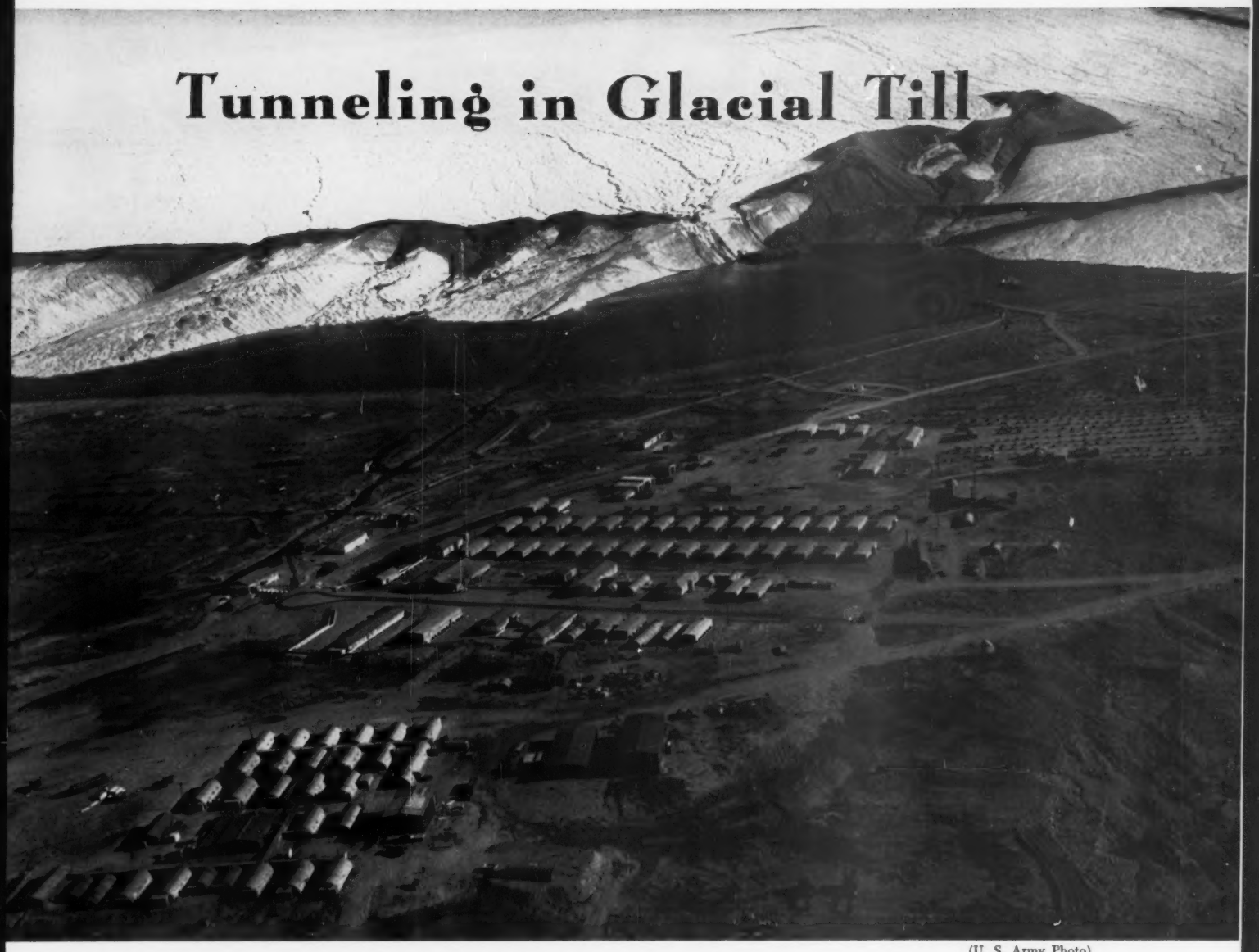
While the protection of children has always been the greatest concern of the Institute, the clippings shown above disclose another side of this problem. These clippings appear on the reverse side of a poster prepared by the I.M.E. to caution all users of the caps to take care. All those familiar with explosives realize that if blasting caps could be kept out of the hands of children, no child would get hurt. For that reason all caps taken from magazines should be accounted for at the end of each day, and caps in storage kept under lock and key.

The poster prepared by the Institute is available at no cost to all users of explosives. Copies can be obtained from member companies of the Institute or by writing to the Institute's offices at 250 East 43rd Street, New York 17, New York.

We are confident that we will be able to enlist your support in this campaign to place the poster where it will be most likely to caution the users of caps to remember the children.

If you will place the poster on your magazine door or in some other conspicuous place, all who have access to your caps will see it, and be reminded to take care of the caps. The number of children injured by blasting caps has declined in recent years, and part of this decline unquestionably can be attributed to the greater care exercised by explosives users in keeping the caps out of the way of children and doing everything to reduce the number of these distressing accidents.

Tunneling in Glacial Till



(U. S. Army Photo)

CAMP TUTO: This excellent aerial view of Camp Tuto, Greenland, the site of the permafrost tunneling activities, shows the extensive surface facilities required for this research project. In the distance may be seen Lake Tuto, the ice tunnel entrance, the camp road, and the ice cap.

A report on some drilling and blasting experiments conducted in the Arctic to determine the feasibility of excavating in the permafrost

JOHN F. ABEL, JR.,* and
ROBERT W. JENNINGS, JR.†

"MANY a strange thing happens in the land of the midnight sun." It is as true today as when Robert William Service penned those words.

An unusual tunnel-engineering project was set into motion in the summer of 1958 when the U. S. Army Corps of Engineers through one of its research organizations, the U. S. Army Snow, Ice and Permafrost Research Establishment (USA SIPRE), Wilmette, Illinois, initiated an investigation of frozen glacial till (permafrost) in Greenland. Personnel of USA SIPRE planned a tunnel, 10 ft. wide by 9 ft. high, to be driven in frozen glacial till, to 100 ft. below the ground surface. The project was part of the overall Arctic research program conducted by the Corps of Engineers since 1951, reflecting the increasing military significance of the Arctic.

The purposes of the tunneling operations were: (1) to determine the feas-

*Carbondale, Colorado
†213 Easter Hill Drive
Grand Junction, Colorado

ibility of excavating underground openings of various sizes in the permafrost; (2) to develop efficient methods for excavating this material; and (3) to determine the characteristics of the glacial till at depth. It is also anticipated that such openings in the Arctic could be utilized as personnel and materiel shelters, away from the severe wind, cold, and snow of the Arctic.

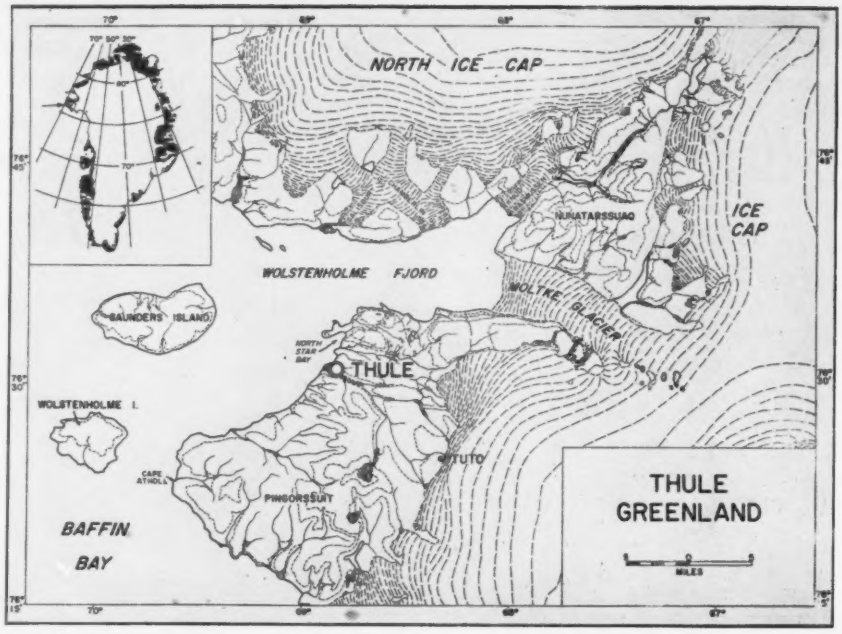
Weather is a primary factor in any construction work in the Far North. Extreme cold in the winter, sometimes 50° below zero, dictates that all outside work be done in the approximately 90-day summer during June, July, and August.

The summer is surprisingly pleasant, with average temperatures at 40°F. and a never-setting sun. The area is subject to violent, unannounced summer storms of high-velocity winds that carry fine ice and snow particles from the Greenland Ice Cap. In one such storm a 97-m.p.h. wind was recorded on the anemometer—the last value recorded before the instrument tower was blown over.

These storms make travel and work out-of-doors impossible; therefore, emergency food rations and blankets must be kept in all the living quarters and at all project sites, for the men could be easily marooned.

The site chosen for the permafrost tunnel was 600 miles from the North Pole along the south side of a valley whose walls are of frozen glacial till. This valley is about ¼ mile west of the Greenland Ice Cap and 1 mile north of Camp Tuto, a Corps of Engineers base for the support of the Arctic research program, 16 miles inland from Thule Air Force Base. A seismic profile, performed in 1958, determined that there was an additional 300 ft. of till below the tunnel level.

The remote location of the tunnel site presented transportation problems. Equipment can be shipped only by water to Thule during July, August, and September when the harbor is relatively free of ice. At other months of the year all equipment must be brought in by air. All the heavy equip-



LOCATION: Tuto, the base of activity, is about one mile from the tunnel and 16 miles inland from Thule Air Force Base. The North Pole is 600 miles distant.

TIMBER LAGGING: It was necessary to install timber lagging around the entire arch in the portal section of the tunnel roof and sides because this area had little inherent strength. Construction of the portal was complicated by the active layer of melted till on the hillside.

ment for the project was selected in 1958 to be brought by sea, a year in advance of the time the field work was actually started. Equipment that could not be delivered in time for sea shipment had to be flown in to the project during the winter.

Before operations could be started it was necessary to construct an access road to the tunnel site and to construct a level bench on the hillside for the surface plant.

Operation

The tunneling on the project was separated, because of the physical state of the till, into two phases. The first phase, construction of the portal and the first 80 ft. of the tunnel, presented the more difficult mining problem because the thawed, unconsolidated active zone required support to prevent caving. The second phase of the operation was the driving of the major portion of the tunnel in competent, permanently frozen ground. No roof support was required in this second phase.

Construction of the portal was complicated by the active layer of melted till on the hillside. Melted till has no inherent strength, since ice was the bonding agent. In the summer months, the uppermost 2 or 3 ft. of the glacial till thaws, becoming an unconsolidated mass of mud and boulders which the moisture tends to lubricate. This active zone of till caved into the tunnel as the supporting permafrost was removed. The permafrost exposed during the portal construction was rapidly melted by the 24-hour sun. It, too, slid into the portal excavation.

To obtain a vertical face into which a tunnel round could be drilled, it was necessary to drive a slot into the hillside. This slot was excavated by blasting seven successively deeper slices from the face of the hillside. The first tunnel round was drilled in the face when the slot was approximately 60 ft. long and 11 ft. high.

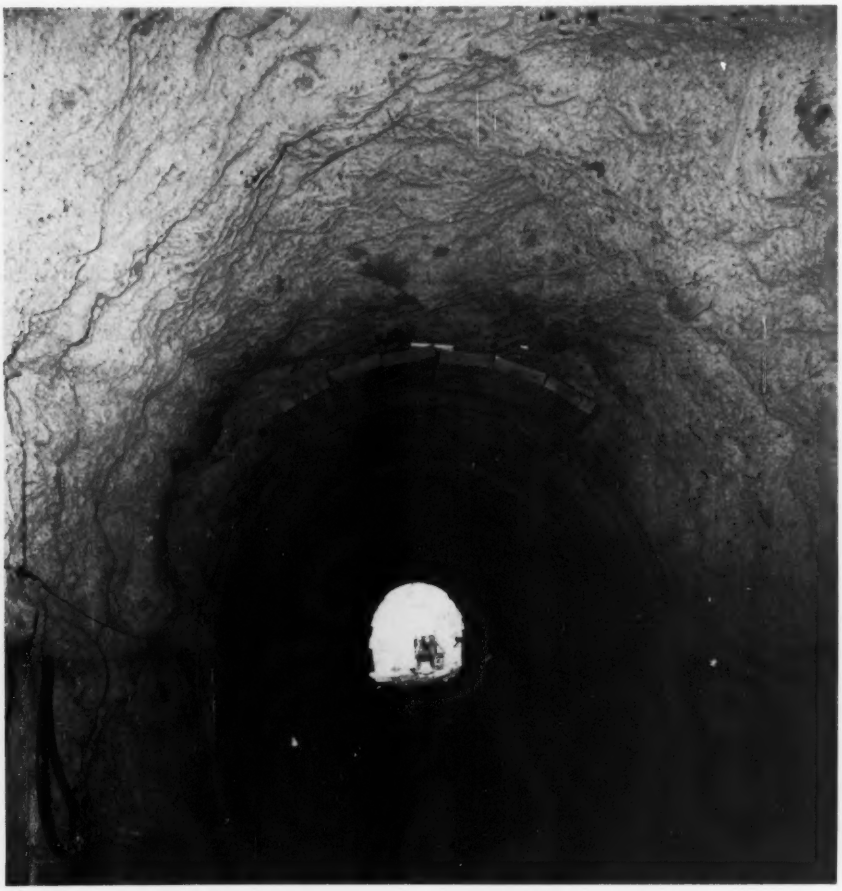
The first three tunnel rounds blasted in the face of the slot broke to the surface of the hillside, rather than breaking out the permafrost as an underground tunnel round as intended.

Great care had to be exercised to protect the men in the slot from rock which fell during drilling, loading, and mucking. The men were protected by overhead timber lagging, on steel arches, carried in contact with the face. This temporary lagging had to be removed before blasting, since there was no way to hold it in place during a blast. After the first successful tunnel round, it was possible to wedge the timber lagging and arches against the roof of the tunnel, thereby holding it in position during blasting.

The face height was approximately 15 ft. when the first successful underground tunnel round was blasted. Since the tunnel height was only 9 ft., the brow at the tunnel portal was then 6 ft., consisting of 4 ft. of load-bearing frozen till and 2 ft. of the unconsolidated active layer.

It was necessary to place steel arches with protective lagging on the sides and top in the portal area, because the frozen till was so close to melting that portions loosened and fell as the result of the heat from the ventilation air. Protective steel arches were a necessary safety measure for the first 78 ft. of the tunnel. The lagging of the sides and top was required for the initial 54 ft. of the tunnel. Only top lagging was used for the remaining 24 ft. of the portal section. Bethlehem yieldable steel arches were selected because of their ease of erection and their ability to adjust to pressures generated when the active layer at the portal freezes during the winter.

After the tunnel was driven in 1959, an experimental room was excavated along the tunnel axis. The dimensions of this room were 20 ft. wide and 25 ft. long. Protective steel arches were



PARTIALLY SUPPORTED: The inner portion of the portal area required only top lagging. Note how the frost on the roof immediately past the last arch has been melted by warm air introduced by natural ventilation.

UNSUPPORTED AREA: Because the temperature in this section of the tunnel is sufficiently low, the permafrost remained frozen and supplied support for the sides and roof.

placed in this area of the tunnel when the roof of the room began to sound "drummy" (hollow) when sounded with a bar. However, this condition corrected itself during the following winter.

Beyond the last protective arch the temperature of the permafrost remained sufficiently low that it did not melt. If melting did occur, it was possible to detect it visibly before it became dangerous. The frost from the humid ventilation air, which covered the tunnel walls, would melt before the permafrost would thaw.

During the winter 1959-60 the information derived from the 1959 field work was evaluated by USA SIPRE. It was decided that most of the engineering questions about permafrost tunneling had been answered; consequently, the project should concentrate on the basic research phase of the problem in the 1960 field season.

In 1960 an additional 300 ft. of tunnel was driven as an extension of the previous tunnel. It was driven with a minimum cross section to allow the operation of the Eimco 12B mucking machine. The dimensions of the tunnel extension were 6 ft. wide by 7 ft. high.

In addition, three rooms were excavated. One was for pile investigations; the second for use as a seismograph installation. The third room, 50 by 50 ft., had three different size pillars. It was anticipated that the mode of failure of roof and pillar could be determined in this room. At the completion of the 1960 operations no failure could be determined. The additional 300 ft. of tunnel allowed the large room to be excavated under a fairly constant overburden and, it was hoped, under uniform stress.

The average advance during tunneling was 2 ft. per shift for the 10 by 9-ft. portal section, 3¼ ft. per shift for the 10 by 9-ft. tunnel section, and 7 ft. per shift for the 6 by 7-ft. tunnel section.

Geology

In order to evaluate the information obtained from the permafrost tunnel research project, it is necessary to understand the character of this permafrost.

A particle-size gradation curve for a mine car-size sample (16 cu. ft.) of the glacial till was developed. This till would be classified as a poorly graded gravel (GP) under the unified soil classification system of the Corps of Engineers. The till is free draining and nonfrost susceptible if thawed; that is, no volume change would occur upon freezing or thawing. Normally, no ice segregation or lensing would be expected to occur in this gravel. Observable free ice was found as a surface film on the bottom of two boulders and in ten thin tabular inclusions. None of these were thicker than ¼ in. Moisture samples taken in the tunnel indicate a wide variation in the water content of the in-place material, averaging about 7% by weight.

The temperature in the tunnel beyond the active layer ranged from 21° to 13° above zero Fahrenheit. The temperature decreased as the overburden increased. Tunneling in this well-frozen glacial till was comparable to tunneling in competent rock.

The major portion, approximately 95% by weight, of the rock material encountered in the tunnel was a granite gneiss. Random fragments composed wholly of the minerals hematite, epidote, or olivene were encountered. A few specimens of competent silicified pink sandstone were also found.

Blasting

Two types of tunnel-blasting rounds were used to excavate the permafrost tunnel: a burn cut and a V-cut round. These were selected because of their ease of drilling with the airleg drills employed. All blast holes in all rounds were drilled with 1⅝-in.-diameter percussion bits.

Twenty-five burn-cut rounds were blasted in 1959 during the excavation

of 118 ft. of the tunnel. These included two 8-ft. rounds, five 6-ft. rounds, and eighteen 4-ft. rounds. The drilling required for the burn-cut round averaged 31.1 ft. of hole per ft. of advance, or 9.9 ft. of hole per cu. yd. of in-place permafrost removed. The drilling time for the tunnel using the burn cut was 0.9 man-hours per ft. of advance.

Forty V-cut rounds were blasted in 1959 during the excavation of 176 ft. of tunnel. Included were two 8-ft. rounds, four 6-ft. rounds, and thirty-four 4-ft. rounds. The drilling required for the V-cut round averaged 34.2 ft. of hole per foot of tunnel advance, or 10.1 ft. of hole per cu. yd. of in-place permafrost removed. The drilling time for the V-cut round was 1.1 man-hours per ft. of advance.

Accurate records of powder consumption were kept for all blasting. The basic philosophy, however, behind the use of powder was: "Powder is the cheapest man on the job." Whenever it was possible to save time with additional explosives, they were used. No stemming was used to reduce loading time. These practices were justified because of the need to complete the tunnel during the short working season. Naturally, high powder factors resulted. Four different explosives were tested in 1959; five were tried in 1960. These explosives are shown in the table.

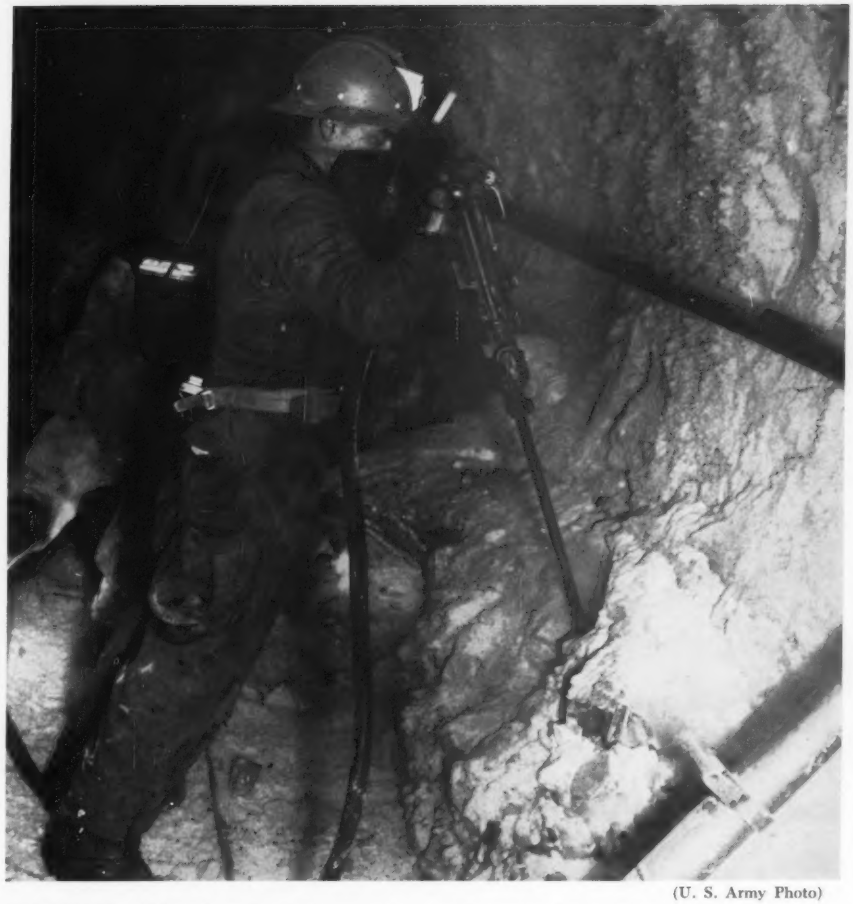
The cost of explosives consumed during the 1959 tunnel excavation was approximately $1,300, or $1.20 per yd. of permafrost blasted. Blasting cap costs were $1,170, or $1.08 per yd. Powder and cap costs totaled $7.60 per ft. of tunnel advance.

While no quantitative data are available about fragmentation sizes, observations indicate that much finer fragmentation was obtained with the high-detonation-velocity explosives. Secondary blasting was required if the round failed to break out the material or if fragments in the muck pile were too large to be loaded by the 4½-cu. ft. bucket of the mine car loader, or into the 16-cu. ft. end-dump mine cars.

The low-detonation-velocity explosives tended to push the material without breaking it into fragments. In one case an unbroken boulder, about 3 ft. in diameter with three drill holes, was found in the muck pile after a blast with a 30% explosive. The finer portion of the permafrost apparently absorbed the force of the explosions; thus, the boulder was dislodged without being broken.

Apparently, the high-detonation-velocity explosives broke the boulders before the softer portions of the permafrost could absorb the shock of the blast. The superiority of the high-detonation-velocity explosives was shown by the higher percentage of satisfactory drill rounds that resulted. This can be seen in the table. No roof damage resulted from any of the tunnel blasting. In fact, the trim holes were visible after blasting.

The drill round that gave the best results in 1959 used a 5-hole burn cut (4 loaded, 1 not loaded), for a total of 35 holes. This was the basis of the drill pattern used in 1960 for the smaller cross-section tunnel. The most efficient explosive tested in 1959 was the 50% nitroglycerin dynamite, and in 1960 the 100% blasting gelatin. Nine standard delay electric blasting caps were used in 1959 and six in 1960.



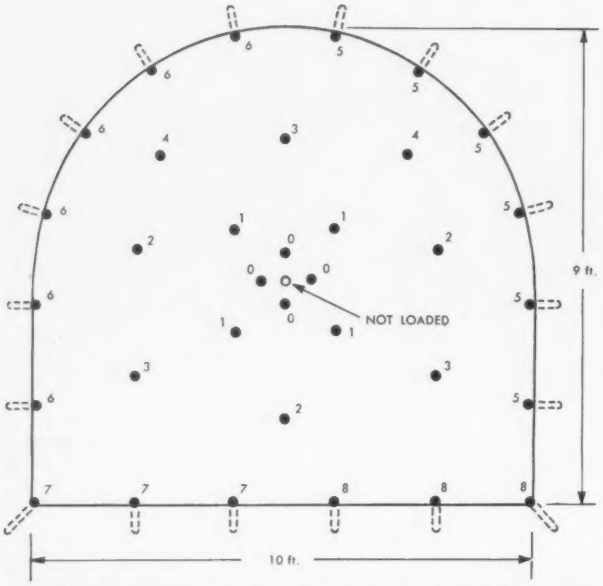
(U. S. Army Photo)

GI MINERS: Although most of the supervisory staff consisted of mining engineers or mining engineering students, the miners were enlisted military personnel having no previous mining experience; consequently, they had to be trained in all phases of the required mining operations.

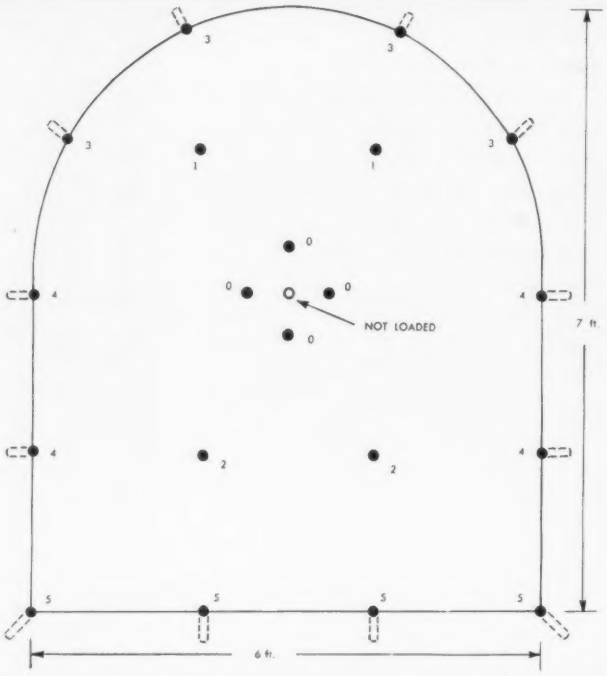
Drilling

Blast hole drilling with airleg-mounted percussion drills and diamond drills was carried on as a part of the project. It was necessary to use an antifreeze drill fluid, 5 to 10% ethylene glycol, to prevent the drills from freezing.

When the permafrost tunnel was planned, it was not known if usable blast holes could be produced with the percussion rock drills; therefore, the diamond drills were purchased as an



1959 DRILL ROUND: In the 10 by 9-ft. tunnel a five-hole burn cut (four loaded and one not loaded) round for a total of 35 holes gave the best results. Numbers beside the holes indicate the delay periods of the caps.



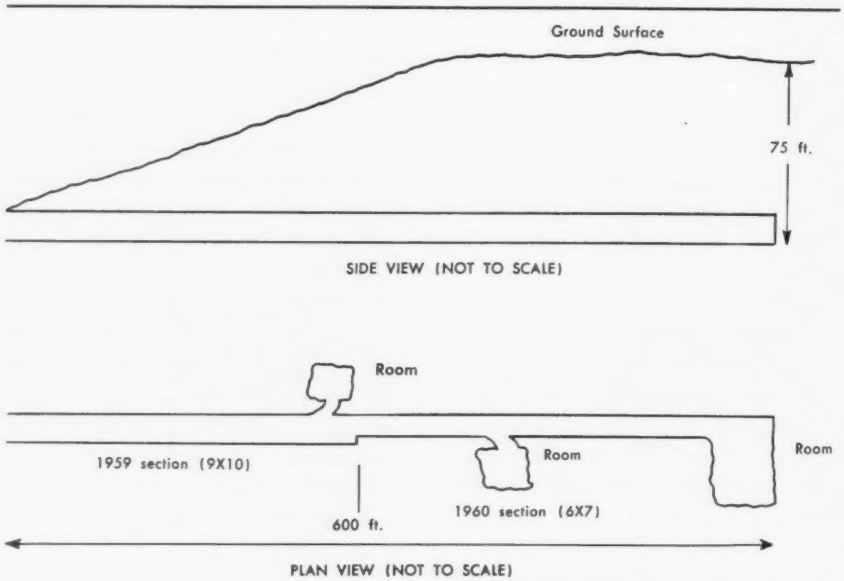
1960 DRILL ROUND: During the second year, a smaller tunnel, 6 by 7 ft., was driven and required a modification of the drill round. This 21-hole round produced good results.

alternative. The percussion drills proved satisfactory in operation. The diamond drill equipment was not tested until after the completion of the 1959 tunnel. This testing indicated the diamond equipment was too slow to compete with the percussion drills in the production of blast holes.

The drilling equipment used was: two Chicago-Pneumatic Co. airleg rock drills, Model CPISL 459W; Gardner-Denver drill steel, 4 and 8 ft.; and Western Rock Bit Mfg. Co. 1⅝-in. tungsten carbide throwaway bits. All equipment was purchased on low bid.

Drilling-rate records were maintained during the tunnel driving. The time required to drill the reported 9,911 ft. of 1⅝-in. drill hole was 9,815 minutes, or an average drilling rate of 1.01 ft. per minute. This overall drilling rate included the time required to prepare the drill platform and to tear it down and remove it, as well as the time to drill out the round. The figure does not represent the penetration rate of the drill, steel, and bit.

The penetration rate of the drilling equipment was determined after the tunnel had been completed in 1959 by drilling a series of timed holes. A total of 159 ft. of hole was drilled with the CPISL 459W drill at an average rate of 2.38 ft. per minute. A penetration-rate test of an Atlas Copco AB Model BBD 41WK rock drill was made at the same time. This test was for comparison of the different percussion rates for the two drills: the CPISL had an approximate percussion rate of 2,000 blows per minute and the BBD about 3,000 blows per minute. The BBD 41WK drilled 142.5 ft. of blast hole at 1.33 ft. per minute. This test indicated



PLAN AND SIDE VIEWS: As indicated on the diagram, the 1959 program called for a 10 by 9-ft. tunnel and a small room. The size of the tunnel was reduced to 6 by 7 ft., and two larger rooms were constructed during the 1960 season.

that a more rapid percussion rate does not speed the drilling rate in this permafrost material.

The typical wear pattern of the bits resulted in the loss of the tungsten carbide inserts. The inserts were lost when that portion of the bit body holding them wore away. Wear of the bit body is apparently the consequence of deep penetration of the bit, with each blow, when drilling in the weaker-softer-finer portions of the till. Dislodged fragments of these finer portions of the till were forced back through the water channels on the bits and ground up by the rotation of the bit. As a result, there was abrasive rubbing of the softer steel body in an augering action. The high proportion of quartz in the till contributed to the rate of wear of the bit body.

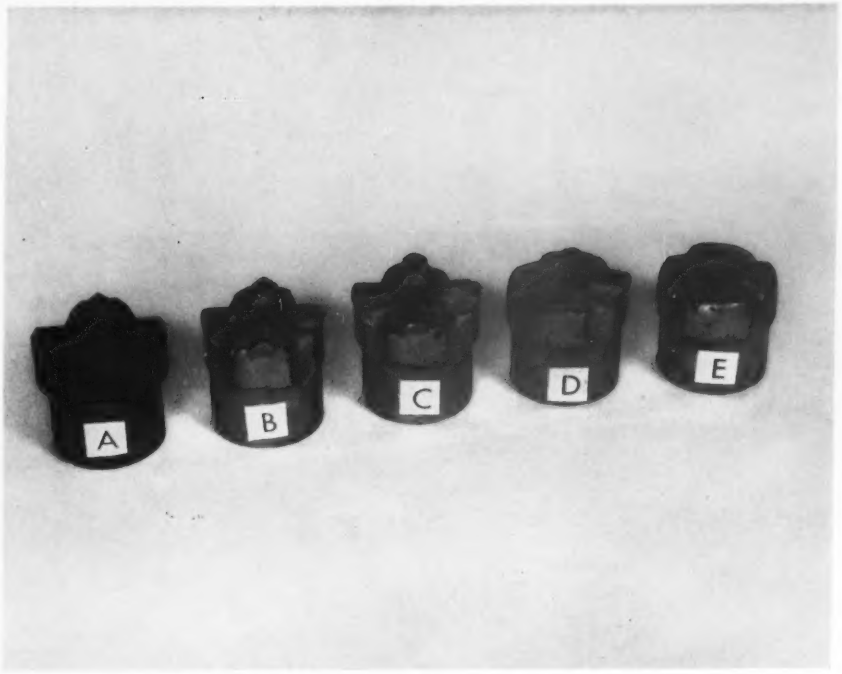
Drilling records were kept for nine drill bits, which were drilled until the inserts were lost. The average bit life for these bits was 212 ft. The bit cost per foot of hole was $.027.

A total of 15 drill bits was destroyed in drilling 11,146 ft. of hole. Seventy more bits were worn but still in usable condition at the end of the season. If half the life is assumed to be left in these 70 bits, then the effective bit consumption was 50. This would give an average footage of 223 ft. per bit, which checks closely the measured footage of the test bits.

The drill steel consumption during the excavation of the 1959 tunnel amounted to five 8-ft. and thirty 4-ft. steels. Of these, 15 were broken and 20 rendered useless when plugged in the water holes. The steel cost averaged $.032 per ft. of hole. The estimated drill steel and bit cost per ft. of 10 by 9-ft. tunnel was $2.12.

Personnel

Supervisory personnel for the tunneling project in the field consisted principally of civilian mining engineers and mining engineering students from the Colorado School of Mines. They have been employed under contract between USA SIPRE and the Denver



TYPICAL WEAR PATTERN: The tungsten carbide drill bits show the typical wear pattern caused by drilling in the permafrost. The average bit life was 212 ft.

PORTAL AREA: The areas around the portal contained only basic facilities needed for the job: haulage track, mucking machines, battery locomotives, and a mine car about to unload at the disposal dump.

SURFACE PLANT: Looking toward the Greenland Ice Cap. Some of the facilities shown are: shop building, waste dump, generator, and compressors, water-storage tank, and powder magazines. The large boulders give an indication of the size of particles in the glacial till.

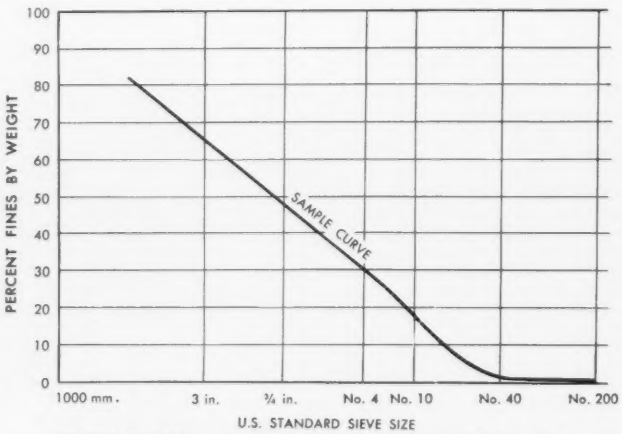
Research Institute of the University of Denver, Denver, Colorado. Dr. G. K. Swinzow, geologist with USA SIPRE, directed the basic research permafrost tunnel project in 1960. The miners were enlisted military personnel attached to the Corps of Engineers supporting organizations.

These military men, untrained previously as miners, had to be trained at the project site. This training was time-consuming, but a necessary part of the safety program. No serious accidents occurred during the two project seasons despite the necessity of completing the operation in a limited time with, for the most part, the inexperienced miners engaged in the work.

TABLE OF BLASTING

1959 Season: 10 by 9-ft. Tunnel

EXPLOSIVES TESTED			SATISFACTORY DRILL ROUNDS		
Name	Weight Strength, %	Detonation Velocity, ft./sec.	No. Attempted, %	Avg. Powder Factor, lb./yd.	Avg. Drill Holes
Gelatin Extra	30	8,500	21	5.1	42
Gelatin Extra	60	8,500	57	5.9	36
Gelamite® 1-X	65	11,500	100	6.6	37
Nitroglycerin Dynamite	50	17,400	100	5.6	35
1960 Season: 6 by 7-ft. Tunnel					
Hercomite® 7-X	65	7,850	54	11.4	21
Gelamite 1-X	65	11,500	81	9.1	21
Extra Dynamite	60	12,450	85	10.0	21
Blasting Gelatin	100	18,500	100	8.8	21
Nitroglycerin Dynamite	60	19,000	93	8.9	21



PERMAFROST TUNNEL GRADATION CURVE: This particle-size gradation curve was developed for a 16-cu. ft. mine car-size sample of glacial till. Sample weight was 915 lb. 3 oz., taken at 53-ft. depth, 250 ft. from portal.

Widening the Panama Canal

Shipping requirements of an expanding world economy made this waterway inadequate. After widening and deepening, it will handle today's superships

CHARLES McG. BRANDL*

NEARLY fifty years have passed since the Panama Canal was first opened to world commerce. During this time the accelerating speed of technological and industrial development has carried man from the leisurely pace of grandpa's horse and buggy into the era of supersonic speed.

*Project Engineer
Panama Canal Company
Balboa, Canal Zone

And on the no longer boundless oceanseas this growth has been reflected in a transition from coal-burning, steam-driven ships to turboelectric, diesel, and now atomic-powered craft. The increase in number and size of the cargo-carrying ships has, since World War II, followed a pattern closely paralleled to the world population explosion. This upsurge, or blossoming, of humanity has thrown out of kilter or rendered obsolete many of the predictions so confidently made by sober economists at the beginning of this era.

The effect of this maritime growth on the Panama Canal has been dramatic. Where only recently it appeared that the Canal would be adequate for many years to come, the tremendous production of the world's

SHALE AND ASH: A view of Zone II showing the typical shale-and-ash flow pattern encountered in that area. This photo was taken just before blasting loosened up the material which was removed by the dipper dredge.

BEFORE—FROM CONTRACTOR'S HILL: Looking south from a vantage point on Contractor's Hill is seen an early stage of the widening operation.

AFTER—FROM CONTRACTOR'S HILL: The difference in width is quite obvious after completion of the contract blasting and grading. The dark line indicates the boundary of the material to be removed by dredging operation.

shipyards responding to the world-wide growth and development now presents problems of capacity which the planners of a decade ago did not anticipate. Instead of having a waterway which would be sufficient for many years to come, the Canal organization must occasionally cope with full-capacity demands and face the certainty that, if apparent trends of economic growth continue, the present capacity will soon be inadequate. Faced with this problem, the Canal organization several years ago began studies aimed at solving it.

Canal-Improvement Studies

These studies covered two phases: the short-range or immediate problem, i.e., for the next few decades; and the long-range question of the ultimate development or disposition of the Canal.

Under the short-range study it became apparent that certain things could be done with the present Canal which would appreciably increase its capacity. These included increasing the efficiency of the locks, lighting Gaillard Cut between Gamboa and Pedro Miguel to facilitate night navigation, and completing the widening of the cut. This article is concerned with the last-mentioned improvement.

The 8-mile section of the Panama Canal between Gamboa, where the Chagres River enters the Canal, and the Pedro Miguel locks is entirely an artificial excavated channel. This channel, which cuts through the Continental Divide at Gold and Contractor's Hill, was originally known as Culebra Cut; but since 1921 it has been called Gaillard Cut in honor of the Army engineer who, under Colonel Goethals, supervised much of the excavation work during the final stages of the first American construction. It was originally excavated to a channel or prism width of 300 ft. and a 45-ft. depth below the 85-ft. (above mean sea level) average Gatun Lake elevation. During the years between 1931 and 1954 one section, or "reach," approximately 1½ miles long was widened to provide a 500-ft.-wide channel. The Canal-improvement studies indicated that the widening and deepening of the entire cut would greatly increase the traffic capacity of the waterway through the elimination of the "clear-cut" restrictions on many vessels now requiring them. The term "clear-cut" is applied to any vessel transiting the Canal which, because of its size, draft, or other factor causing difficulty in navigation or because of the nature of its cargo, i.e., explosive or highly flammable, must proceed unimpeded through the 8 miles of the Cut channel. While it proceeds at a slow pace or under tow no other vessel may pass, and the delays to other shipping caused by this procedure are significant. Since the economic advantages of large vessels are obvious, more and more supersize ore, crude oil, or other bulk-cargo ships are being built. With present channel conditions most of these vessels would have to be designated "clear-cuts."

Wider Channel

The Canal's studies indicated that a 500-ft.-wide, 50-ft.-deep channel would be the most practical improvement which was economically feasible. Such a channel would eliminate many, although not all, of the "clear-cut" bottlenecks.

For reasons of stability and convenience it was decided to do all the widening along the west side of the Canal, which runs roughly north and south. Starting in 1958 at a point just north of Pedro Miguel locks, work has continued under different contracts for the removal of all material above elevation 95, including final slopes away from the new Canal bank. In the approximate 250 ft. required for widening, all material below elevation 95 is drilled and blasted by the contractor and subsequently removed by Panama Canal Company dredges.

The first contract for the widening covered a ¾-mile section just north of Pedro Miguel locks. This work was performed in 1958-59. In 1959 the Paraiso-Cucaracha Reach Widening contract was awarded to the firm of Merritt-Chapman & Scott. Work was started in April of 1959 and was finished late in 1960. Included in the work were the excavation and removal of approximately 5¾ million cu. yd. of unclassified excavation above elevation 95, about 40% of which was rock requiring blasting; drilling and blasting about 3 million cu. yd. of material between elevations 32 and 95 to be removed later by dipper dredges; the relocation of a signal station, a concrete spillway, and part of a highway.

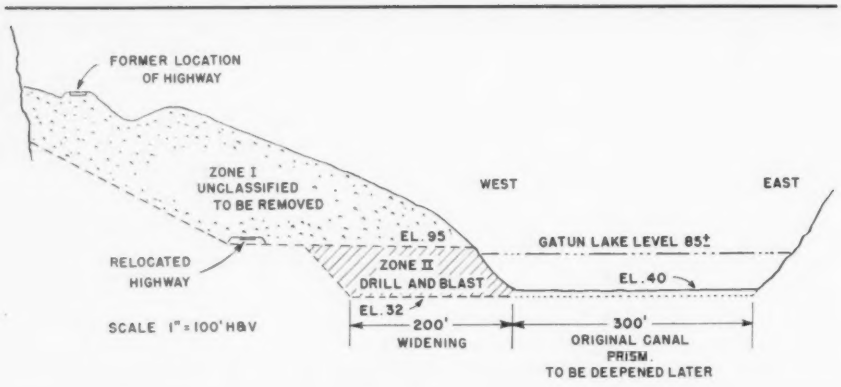
The general excavation in Zone I, as the work above elevation 95 was designated, proceeded along conventional lines, using large trucks and power shovels. Two 4-yd. and two 6-yd. shovels (Limas) and 24 large trucks (I.H. Payhaulers) were supported by bulldozers, patrol graders, truck cranes, sprinklers, etc. Three DW-21 scrapers were also used. Haul distances to spoil dumps averaged approximately a mile. About 20,000 cu. yd. was the daily production average for the two 10-hour shifts during the period of the most intense activity.

Drilling and Blasting

Most of the drilling was done with six Joy 550 and two Air Trac drills, with jackhammers doing supplementary drilling. Air power was obtained from a battery of six 900-c.f.m. Gardner-Denver electrically driven compressors in a central plant. Lightweight spiral steel pipe from 10 down to 4 in. was used for distribution. Drilling and blasting patterns varied with the location and nature of the rock. Three types of rock were encountered. These were a very hard basalt, a hard formation known as Pedro Miguel agglomerate, and a very hard, brittle formation known as "ash flow." On occasion, the relatively soft shale was blasted to loosen its compaction. All material involved was of volcanic origin. The most common pattern used was a 10 by 10-diamond, with holes 40 ft. in depth. Loading varied from a few hundred lb. to 20 tons, with an

DRILLING: A skid-mounted Boyle Bros. angle drill (left) is at work making 30- and 15-degree holes along the sloping canal bank. Other pieces of drilling equipment shown are an Ingersoll-Rand 600 Drillmaster and a Model PR-10 Robbins.

BLAST IN ROCK: A typical hard rock blast. In this agglomerate area the blast consisted of 39,550 lb. of 60% gelatin dynamite. The seismograph record showed only normal vibrations.



CROSS SECTION: The canal in the Paraiso-Cucaracha reach section was 300 ft. wide. After the improvements are completed, the width will be 500 ft. and permit larger craft to use this link between the Atlantic and the Pacific Oceans.

average of approximately 8,000 lb. Total powder used in Zone I blasting (60% and 40% gelatin and semigelatin and nitro carbo nitrate) was 1,037,575 lb. This represents a factor of slightly less than ½ lb. per cu. yd. of material blasted. Owing to the very high lightning incidence, all blasting on the project was detonated with Primacord.* Millisecond delay caps, which were used on branch lines in the pattern, were applied just prior to detonation and when no lightning hazard was present. Results were generally good.

The Zone II (below elevation 95 and down to elevation 35 which is 50 ft. below the average water level of the Canal) drilling and blasting were matters of serious concern for the Panama Canal authorities. The results of this work, which would be removed by the Canal's dredges, could not be known until the dredging progressed. This was done as closely as practical following the blast but sometimes it was necessary to wait several months for the removal of certain patterns. A high degree of fragmentation was required since the effect of rock too large to pass through the 13½-cu. yd. dredge bucket involved costly delays for the dredge while such fragments were removed, usually by jackhammer drilling and blasting in the bucket.

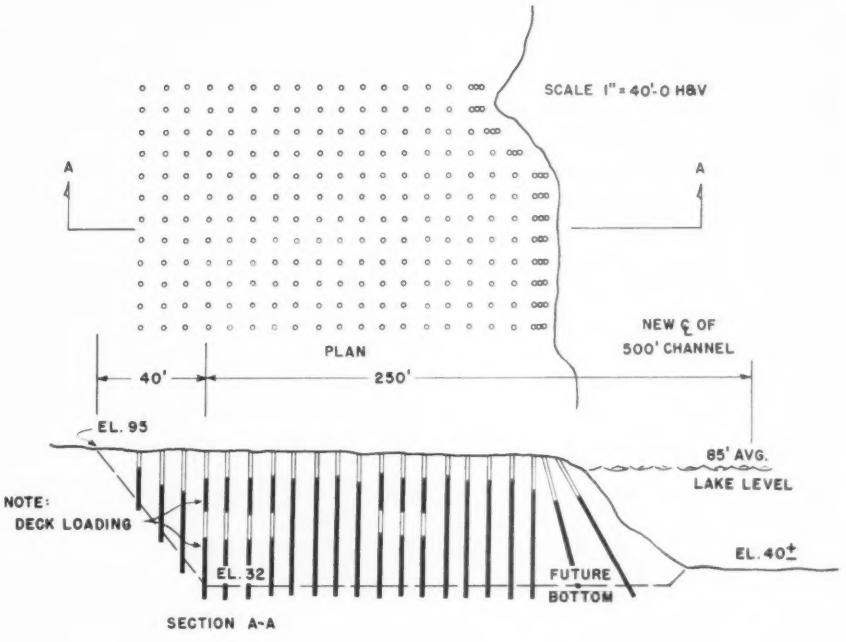
The rotary drilling equipment used on the Zone II work consisted of two I-R track-mounted 600 Drillmasters, one Robbins tractor-mounted (Model PR-10), and one skid-mounted Boyle Bros. angle drill. This rig was especially effective in drilling the 30- and 15-degree holes required along the sloping Canal bank. Hole sizes varied according to the nature of the material. Three-, 4-, and 5-in.-diameter holes were drilled. Both tricone and fishtail bits were used. Patterns generally were 10 by 10 ft. with closer spacing along the Canal bank and in certain very hard formations. Equip-

*Reg. U. S. Pat. Off. by The Ensign-Bickford Company

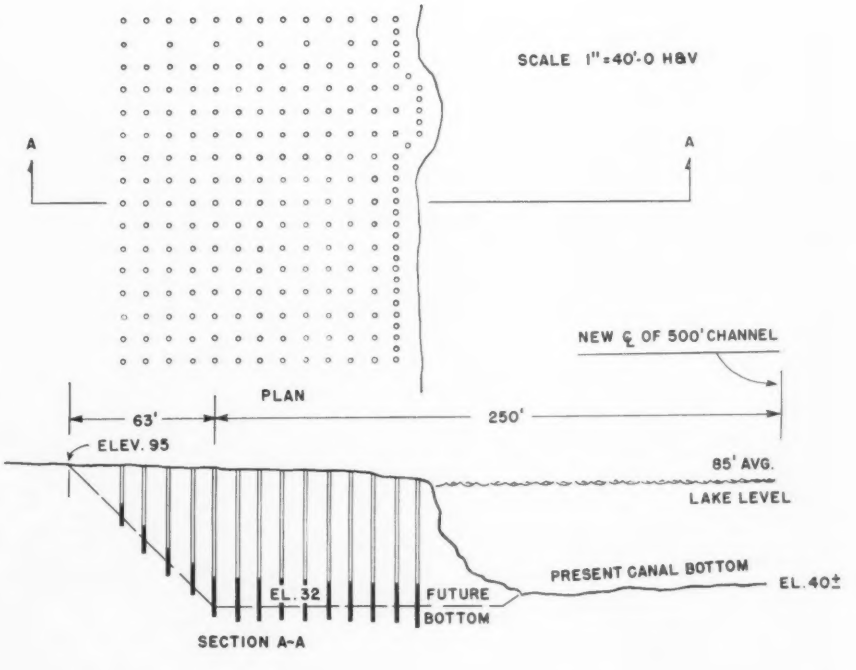
BLAST RESULTS: In the ash-and-shale areas good results were obtained in the blasting operations. Note the character of the breakage, which meant easy handling by the dipper dredge, and the absence of rock thrown toward the canal.

ment used in Zone II was owned by Selby Drilling Corporation which, as a subcontractor for Merritt-Chapman & Scott, did the drilling, loading, and blasting in this zone. All material in Zone II was blasted. Because of the nature of this material, extensive deck loading was required to contain the explosive force where layers of hard material were separated by softer shales. Considerable drilling difficulty resulted from this condition, necessitating the use of casing for many holes. Dry drilling was used at the beginning of work in Zone II, but the great difficulty of removing cuttings and retaining a clean hole for loading caused the subcontractor to change his procedures to wet drilling. Pumps were installed on a float alongside in the Canal and the results indicated the wet method was far superior. Drilling speeds varied from a few inches to several feet per minute depending on the hardness and inclination of the material. A total of 49 patterns was used for the entire Zone II work. The total drilling included 88,257 lin. ft. of 3-in., 468,166 lin. ft. of 4-in., and 249,806 lin. ft. of 5-in.-diameter holes into which 1,680,301 lb. of 60% water-resistant packaged gelatin-type dynamite was loaded and detonated. The maximum pattern fired used 25 tons of explosive, but the seismic effects were so severe that thereafter the maximum permissible loading was held to a limit of 20 tons, with 17 tons the average. Waterproof, plastic-reinforced Primacord was used in all the holes and regular-reinforced Primacord for most of the trunk and branch lines. Millisecond delay caps were used in a similar manner as in Zone I. All blasts were recorded on the seismograph located at Balboa Heights, approximately 10 miles from the blast area.

Progress on the Zone II work was slow at first but after the change to wet drilling it went rapidly and finished several months ahead of the original schedule. At the end of 1960 more than 75% of the blasted material had been removed by the dipper dredge and the results have been generally satisfactory. When this dredging



HARD ROCK DRILL PATTERN: In the agglomerate area of Zone II the average blast contained 39,550 lb. of 60% water-resistant packaged gelatin-type dynamite loading in 243 four-in.-diameter holes. Average spacing was 10 by 10 ft. Deck loading was used in some locations.



SHALE DRILL PATTERN: A blast in the shale area of Zone II normally consisted of 221 five-in.-diameter holes containing a total of 36,272 lb. of dynamite. Seismic readings were made of all blasts to make sure vibrations were kept within specified limits.

work is completed, about half of the 8 miles of Gaillard Cut will be widened to provide the 500-ft. design channel. This in itself will help appreciably in reducing the delays to ships passing through the Cut. Meanwhile, work is in progress widening and deepening adjoining Empire Reach. Studies are under way preparing for the final contracts to effect the same improvements to Cascadas and Bas Obispo Reaches, which will finish the Cut widening. After the deepening of the old 300-ft.-wide channel this phase of the Canal-improvement program will be complete and a considerable increase in capacity will have been achieved.

Safety Record

One feature of the work deserving special mention was the generally fine safety record. The proximity of the Canal made it imperative that extreme caution be taken to avoid injury or delay to passing vessels. This included hazards from flyrock as well as the possible damage or delay which might result from a massive rock fall into the Canal. Neither of these mishaps occurred. It is a matter of pride for the contractor and for the Government inspection personnel that, despite the almost ceaseless flow of ships through the area, none was delayed an instant because of the work in progress. Nor did this care impose any significant burden on the contractors since most of the blasting could be done during the lunch break or at the change of shift. It did require a more than average alertness and coordination between the inspection forces and the blaster but the care exercised was reflected in the attitude of the workmen toward other hazardous activities, and the entire project was very "hard hat" conscious.

This work was accomplished under the direction of Lieutenant Colonel Robert D. Brown, Jr., C.E., U.S.A., engineering and construction director and contracting officer for the Panama Canal Company/Canal Zone Government. For the contractor, Merritt-Chapman & Scott, the project manager was F. M. Esielonis. Charles G. Kincaid was project superintendent for Selby Drilling Corporation on the Zone II drilling and blasting work.

EASY DIGGING: A 12-cu. yd. dipper dredge removes blasted material in Zone II as drilling proceeds in an adjoining area for the next blast.

UNLIMITED RESERVE: The McMillan Quarry, located about 5 miles from El Paso, is being worked into the east side of Franklin Mountain. From this view of the quarry and the mountain in the background one can understand that the rock reserve is practically unlimited.

Quarrying West of the Pecos

Efficient quarry-blasting methods enable Hugh McMillan, Inc., to meet the demands of a rapidly expanding area

WILLIAM K. HAYS*

On the Rio Grande at the junction of Texas, New Mexico, and Mexico is the bustling and thriving city of El Paso—the westernmost city of Texas and the hub of industrial and agricultural activity of the Trans-Pecos region.

According to preliminary data from the 1960 census, the population of El Paso has increased over 100%—from 130,485 to 276,687—during the ten-year period from 1950 to 1960. This is extremely rapid growth, even for Texans who have always been accustomed to doing things in a big way.

There are several reasons for this phenomenal growth. Not necessarily in the order of their importance, the growth can be attributed to agriculture, military, and industry.

The Upper Rio Grande Valley, which extends 100 miles above and below El Paso, has, since the introduction of irrigation to the semiarid chaparral country, become a fertile area of productive farms and orchards. The excellent soil is ideal for the growing of long staple cotton, an important industrial raw material.

The rapid expansion of nearby Army and Air Force installations has been no small factor in the development of the area. Approximately 5 miles from the center of El Paso is Fort Bliss, one of the largest military reservations in the nation and a center for experiments in jet-propelled missiles. Biggs Air Force Base adjoins Fort Bliss and here is stationed a segment of the Strategic Air Command. The greatly expanded activities at these two installations have added many hundreds of people, both military and civilian, to the population rolls.

Industrially, the area is noted for its facilities for the primary smelting and

*Hercules Powder Company
Joplin, Missouri

A PRIMARY BLAST: The size of primary blasts varies, depending on the demand for stone. Good breakage is obtained by using a 12-ft. burden and 6-ft. spacings, with the holes loaded with a bottom charge of Gelamite 2 on which is poured Hercol bag powder.

GOOD BREAKAGE: The usual primary blast produces well-broken rock, properly laid for easy handling by the two Northwest shovels. It requires about ¾ lb. of explosives to produce a cubic yard of broken rock.

refining of ores, for petroleum refining, apparel manufacturing, and for the production of building materials.

The McMillan Quarry

Among the progressive companies serving the building industry is McMillan Quarry, Inc., producer of dolomitic limestone for road building and general construction. The McMillan company operates one of the most unusual quarries in the Southwest. Located at an approximate altitude of 4,000 ft., the quarry is in the east side of Franklin Mountain and has been worked since 1946. Although located about 5 miles on U. S. 80 from the center of El Paso, the quarry is still within the city limits. The property, which comprises, in addition to the quarry area, crusher, offices, and repair shops, totals about 400 acres. When one looks at the mountain into which the quarry is being worked, he can well realize that the rock reserve is almost unlimited.

The actual quarry area is in the shape of an inverted U and extends about 2,000 ft. The height varies from 180 ft. to 0 ft. on one side of the U and from 50 ft. to 0 ft. on the other.

Throughout the years production has increased and has met the demands of the highway-building program, the growth of the city, and the expansion of the military facilities in the area. Current production ranges from 2,000 to 5,000 cu. yd. a day, depending upon the type of material being quarried. This production rate is about double the 1950 output.

The dolomitic limestone quarried at the McMillan Quarry is tough and abrasive. Chemical analysis shows that the rock contains in varying degrees, depending upon the area quarried, silica, iron oxide, alumina, lime, magnesia, and carbon dioxide. Compressive strength tests show the stone is ideally suited for road building and other construction when high compressive strength is needed.

Drilling

Operation of the quarry does not require the removal of any overburden, for the rock formation extends right to the surface. In the few areas where there is some overburden, it is so thin it can be ignored.

One minor difficulty experienced in

HAND WORK: Many Mexican builders contract with McMillan for stone just as it lies in the quarry. Their own crews hand-pick the rock and, where necessary, use several blows of a 20-lb. sledge to reduce it to a size that can be handled by the husky laborers.

the operation of the quarry is that of drilling. The sharply inclined terrain does not permit the use of large-diameter drills; consequently it requires the use of wagon- and Air Trac-types of drills. Gardner-Denver Air Trac ATD-3000, Models WHD123J and BH-99, wagon-type drills have been successfully operated in this difficult location. Using Timken 3-in. carbide insert bits attached to CL-5-700 series sectional drill steel, the Air Trac units sink bore holes. Vascaloy 2¼-in. carbide insert bits and 1¼-in. sectional drill steel are used with the Gardner-Denver wagon drills.

Considering the toughness and the abrasiveness of the rock, the rate of penetration—500 ft. from the wagon drills and 700 ft. using the Air Tracs per 8 hours—is satisfactory. After drilling 700 ft., it is necessary to resharpen the bits; after drilling a total of approximately 2,000 ft. the bits are discarded.

Thor, Model 55, drills make the holes for secondary blasting, using either 1¼- or 1⅞-in. Timken carbide insert bits. Gardner-Denver ⅞-in. hex. drill steel is used in this operation.

Five compressors supply the air needs of the various drilling equipment. Two Gardner-Denver, Model 600, and one Gardner-Denver 315 are portable units and take care of the drills for the secondary blasting and the blasting in the caliche area. Two stationary units, an Ingersoll-Rand with 1,240-cu. ft. capacity, and a Gardner-Denver 900, are required for the Air Tracs and wagon drills on the top.

Blasting

The usual primary blast consists of a varying number of 2¼ to 3-in.-diameter holes ranging from 70 to 100 ft. in depth, depending upon the height of

the face. The number of holes in each primary blast depends, of course, upon the demand for stone. Holes are drilled with 12-ft. burden and 6-ft. spacing. The average 100-ft. dry hole will have in the bottom 50 lb. of Gelamite® 2 in 2 by 24-in. cartridges. On this is poured 550 lb. of Hercol®, a free-flowing bag powder especially suitable for loading dry vertical drill holes. No stemming is required. Charges in the down holes are primed with plastic-reinforced Primacord.* A No Vent® Short-Period Delay Electric Blasting Cap, periods 1 to 12, depending on number of holes in the blast, is attached to the end of each Primacord down line. This is pushed into the top of the hole, which is then filled with rock screenings to help eliminate the sharp cracking noise on detonation. The blast is detonated by a plunger-type blasting machine. The average blast will require ¾ lb. of explosives to produce a cu. yd. of broken rock.

*Reg. U. S. Pat. Off. by The Ensign-Bickford Company

The nature of the rock strata makes some secondary blasting necessary. To reduce such rock to a size for easy handling by the shovel, Hercomite® 4, 1¼ by 8-in. cartridges, and cap and fuse are used.

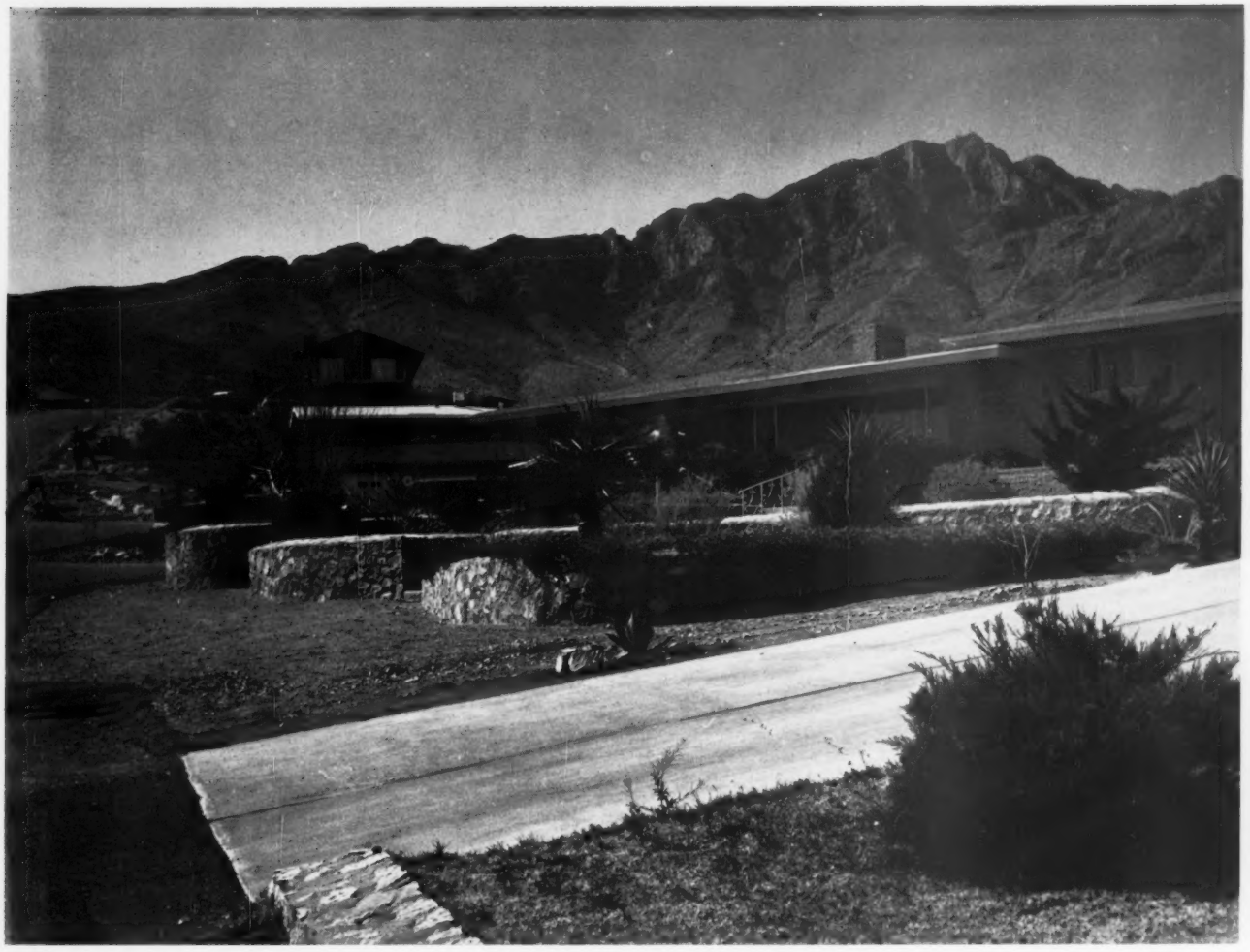
Two Northwest Model 6 with 1½-cu. yd. dippers do an excellent job of loading the blasted rock in a fleet of rented 2-ton Chevrolet trucks for transportation to the crusher and to the stockpile.

Mexican Craftsmen

Although the quarry is completely mechanized and utilizes the very latest in equipment, a visitor is liable to get the impression that rather primitive methods are used. This snap decision is caused by the sight of many workers swarming over the rock pile and breaking the rock with heavy sledge hammers.

The quality and color of the stone produced at McMillan Quarry make it ideally suited for boundary walls, fences, and picturesque architectural uses. Many Mexican builders from both El Paso and its twin, International Ciudad Juarez, contract with McMillan for this stone just as it lies in the quarry. Mexican crews hand-pick the desired rocks and, if too large for convenient handling, will break them by several blows of a 20-lb. sledge. It's mighty tough work, but they never seem to falter, and the sledging and hand removal of the stone to the waiting trucks continue all day long. The

ARTISTS AT WORK: The quality and color of the rock produced at the McMillan Quarry make it ideal for architectural uses. When combined with the Mexicans' skill, many beautiful boundary walls and fences result.



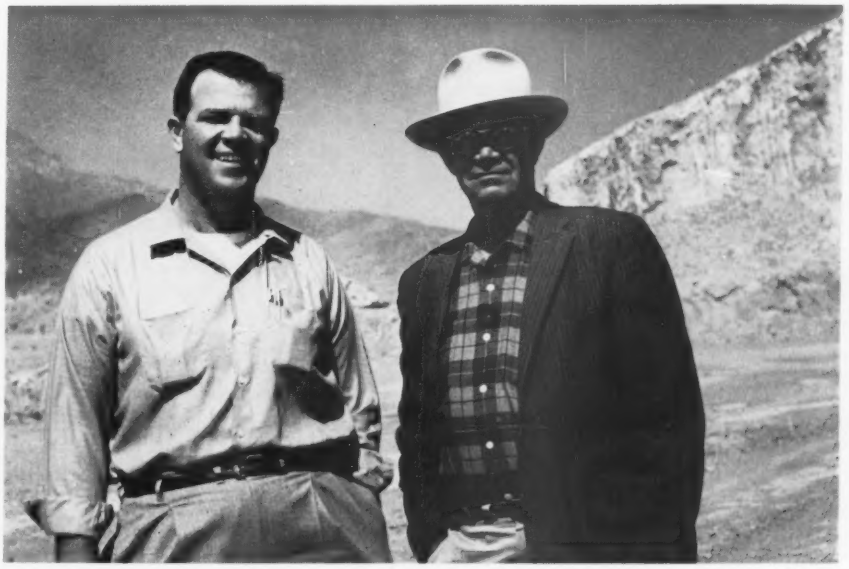
GRACIOUS LIVING: In the more exclusives sections of El Paso and its stylish suburban developments, McMillan stone has combined with Mexican artists to produce unusually striking effects.

men are true artisans, as examples of their construction work prove.

Safety

Safety indoctrination is a bilingual project because most of the employes at the quarry are either Mexican or of Mexican heritage. The key men who attend the regularly scheduled safety meetings are bilingual; it is their duty to convey the safety messages to the Spanish-speaking workers under their supervision. Bonuses are given to supervisors who achieve good safety records.

In addition to Hugh McMillan, president, and W. E. Tucker, vice president and general manager, the management staff consists of Martin Armendariz, quarry foreman; Cecil J. Chisholm, safety engineer; Juan Rojas, blasting foreman; and his assistant, Sefreno Granabo.



VIEWING THE RESULTS: Explosives Engineer Bill Hays and W. E. Tucker, vice president and general manager of McMillan Quarry, Inc., seem pleased with the well-broken rock resulting from the primary blast just fired.

Small Loadings of Dynamite Remove Curb

Skillful use of dynamite removed 300 ft. of concrete curbing in six hours, representing a savings of nearly three weeks' time when compared with normal removal methods

WILLIAM F. HALLSTEAD°

AFTER a jackhammer crew had chipped off a skimpy 50 ft. of tough concrete curbing in three days, the 300-ft.-long job was turned over to an experienced blasting firm. The skillful use of dynamite completed the work in six hours.

The project was the recent removal of a curbing in the middle of heavily traveled Eastern Boulevard, a four-lane divided highway in Baltimore, Maryland. Where this highway passed the sprawling Martin Company east of Baltimore, its intersection with Wilson Point Road was being channelized. The strip of curb, 18 in. wide and 12 in. in depth, was in the midst of the proposed channelization and had to be removed.

°517 Wyngate Road
Lutherville, Maryland

Heavy traffic uses this main artery, and not 150 ft. north, it is paralleled by the main line of the Pennsylvania Railroad between Baltimore and Philadelphia. The idea was to knock out the curb but to keep traffic on both Eastern Boulevard and the railroad moving except during actual firing.

Test shots showed the most efficient pattern to be ¼-cartridge loadings of 40% gelatin extra dynamite placed in 10-in.-deep bore holes on 24-in. centers down the centerline of the curbing. These were placed in groups of four and fired with electric blasting caps by a twist-type blasting machine. Each loading was covered with a 12 by 12-ft. blasting mat of ⅝-in. cable. The mat was placed over the charged holes with a Warner-Swasey Gradall.

Fly was minor, with even the largest debris not much larger than a pebble; thus traffic was interrupted only during the minute or so required for the actual firing.

After drilling was completed, the work progressed at the rate of one shot every six minutes, each shot thoroughly fracturing 6 ft. of curbing. There was no damage to the abutting pavement.

In six hours—less than one working day—the curbing was demolished by the three-man blasting team. At the rate the jackhammers had been moving, this same work would have required three weeks.

The prime contractor was Harry T. Campbell Sons' Corporation, Baltimore, Maryland. Explosives were placed and fired by Burnbrae, Inc., also of Baltimore.

THE CURBING: The curbing was removed by small blasts. Each charge was primed with an electric blasting cap and fired simultaneously by a twist-type blasting machine.

A BLAST: Each blast thoroughly fractured 6 ft. of the curbing, with no damage to the abutting pavement. A ⅝-in. cable mat placed over the charged holes prevented flyrock.

CURB REMOVED: It required only six hours for the three-man blasting crew to remove the 300 ft. of curbing. Traffic was uninterrupted except during the actual blasting.

NEWS NOTES

BUREAU OF MINES RELEASE

Changes in explosibility of a mixture of coal dust and air, because of the presence of varying amounts of a combustible gas, are described in a Bureau of Mines technical publication just released by the Department of the Interior.

During experiments at the Bureau's Health and Safety Research and Testing Center, Pittsburgh, Pennsylvania, the gas—methane—common in many coal mines was exploded with bituminous dust. Two sizes of laboratory-type test chambers were used to simulate mine atmospheres. Some of the conclusions, the Bureau said, are applicable to any combustible gas present in a potentially explosive dusty atmosphere.

Effects of changes in pressure and convection currents within the test chamber also are discussed in the report and should interest industries other than coal, the Bureau added.

Report of Investigation 5815, "Explosibility of Coal Dust in an Atmosphere Containing a Low Percentage of Methane," was written by John Nagy and William M. Portman. A copy can be obtained from the Publications-Distribution Section, Bureau of Mines, 4800 Forbes Avenue, Pittsburgh 13, Pennsylvania.

TRACTOR-MOUNTED COMPRESSORS

A new range of tractor-mounted air compressors capable of delivering 125 cu. ft. of air per minute at pressures up to 100 p.s.i. was announced recently by Atlas Copco, Inc.

According to the company, these compressors, designed to draw their power supply from the tractor motor, are two-cylinder, two-stage, single-acting, air-cooled, V-type units with intercooling between stages. Easy to operate and equipped with adjustable connecting points, these compressors are intended for mounting on tractors with three-point hydraulic linkage systems. Supplied with a splined propeller shaft for connection to the tractor power take-off, air power can be provided quickly. Mounting and dismounting are carried out in minutes. Write Atlas Copco, 545 Fifth Avenue, New York City.

BACKHOE BULLETIN

A four-page illustrated folder describing the features of the new Ottawa LX backhoe for wheel loaders has been released by Equipment Division, Young Spring & Wire Corporation, Bowling Green, Ohio.

The two-color booklet graphically portrays the Ottawa Hydra-Hitch that allows the removal or attachment of the backhoe to the loader in only 30 seconds. The Hydra-Hitch works equally well on level or rough terrain. Other features illustrated are the Ottawa "One-Trol" levers for simple, fast control; types of buckets available; and the dirt-ejector buckets that automatically exert a 10,000-lb. hydraulic force to clean sticky material out of the bucket. The booklet also lists construction features of the backhoe, gives complete specifications, and provides a working-range chart for digging depth, dumping height, reach, and other dimensions.

Copies of the new Ottawa LX backhoe folder are available from Equipment Division, Young Spring & Wire Corporation, Bowling Green, Ohio.

ROCK MECHANICS SYMPOSIUM

The Fifth Rock Mechanics Symposium will be held at the University of Minnesota, May 3 to 5, 1962. Jointly sponsored by the mining departments of the Colorado School of Mines, the Missouri School of Mines and Metallurgy, the Pennsylvania State University, and the University of Minnesota, the symposium will deal primarily with problems of "dynamic" rock mechanics, although significant advances in other areas will also be included. It is tentatively proposed to hold five technical sessions in the 2½-day meeting, devoted to the following topics: drilling; blasting; comminution; "dynamic" physical properties of rocks; theories of rock failure and "static" physical properties of rock; and other important contributions, as determined from papers submitted for consideration.

Registration details can be obtained from Center for Continuation Study, University of Minnesota, Minneapolis 14, Minnesota.

LIQUID OXYGEN CYLINDER

A liquid oxygen cylinder with a capacity of 3,000 cu. ft. of oxygen is described in a booklet now available from Linde Company, Division of Union Carbide Corporation. The manufacturer claims the large-capacity Linde LC-3 cylinder supplies the equivalent of 12 "K"-type high-pressure cylinders. The cylinder's weight is only 463 lb. and requires only ⅓ the space in storage or operation as its equivalent in high-pressure cylinders. The compact LC-3 delivers 300 cu. ft. of oxygen per hour at pressures up to 75 p.s.i. Because of its relatively light weight and large capacity, the LC-3 is suitable for use whenever more than 5,000 cu. ft. of cylinder oxygen per month is consumed. According to the manufacturer, the LC-3 meets all ICC safety specifications and can be shipped over highways in any type of common carrier. In addition to the LC-3 liquid oxygen cylinder, similar cylinders for use with liquid nitrogen and liquid argon are described.

For free copies write to Linde Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, New York.

WORK-GLOVE CATALOG

Industrial work gloves covering a wide range of uses and materials are described in a bulletin released by Mine Safety Appliances Company, Pittsburgh.

The illustrated leaflet provides descriptive details on 12 types of gloves, including leather and leather palm in various styles, terry cloth in both standard and reversible types, double-palm flannel, and hot mill in gauntlet and band-top styles. Special features of individual glove types are also listed.

Copies of the bulletin are available on request from Mine Safety Appliances Company, 201 North Braddock Avenue, Pittsburgh 8, Pennsylvania.

CONSTRUCTION DRILLING BITS

Newest in their line of rotary drilling bits are the CB construction bits manufactured by Varel Manufacturing Company, 9230 Denton Drive, Dallas 20, Texas.

Designed to withstand the toughest drilling in construction work, the three-way CB bits are made in sizes 1⅞ through 2⅞ in. and the four-way bits are from 3 to 4¼ in. in diameter. The extra-heavy carbide tips are applied in machined slots by a brazing process. Illustrated catalog pages show side and top view of both bits, along with complete information as to diameter, pin sizes, and prices.

PARSONS-SHAWNEE BULLETIN

Parsons-Shawnee backhoes are the subject of a new bulletin released by the Parsons Company, manufacturer of trenching equipment and utility tractor attachments.

The line includes four Parsons-Shawnee backhoes: the 1000, with a 10-ft.-deep digging capacity; the 12-ft. 1200; the 13-ft. 1300; and the 15-ft. 1500. The booklet describes many advantages and illustrates "Hydaway" hydraulics with cylinders, pistons, and hoses enclosed and protected; three-position dig-all bucket; nonskid stabilizers; safety locks on both boom and swing; multiple series control; rubber stops on frame to cushion against swing mechanism; and full 180° swing.

Complete specifications on all models are also included in the bulletin, as are picture-stories of other Parsons-Shawnee equipment. Copies are available from The Parsons Company, Newton, Iowa.

SIDESHIELD FOR SAFETY GLASSES

A new, flat, half-type plastic sideshield in crystal-clear or green for plastic safety glasses is being offered by Willson Products. The new sideshields are cemented to temples and fit spatula or plastic-cable styles. Tests by the maker show Willson's Clear-Vue sideshields improve side visibility and ventilation. Compact in design, this new Willson product has received wide worker acceptance. Additional information may be obtained from Willson Products Division, Reading, Pennsylvania.

BATTELLE INSTITUTE BULLETIN

Can the Research Scientist Acquire a Management Attitude? is the title of, and the basic question underlying, a printed discussion now being offered by Battelle Memorial Institute to representatives of industry concerned with research and development. Written by M. R. Nestor, Battelle's manager of project development, the discussion is one of a series on the procedures and characteristics of contract research for industry being published by the Columbus, Ohio, research center.

The discussion makes the point that industrial management people and research professionals have much in common, including a high degree of creativeness. Industry's practical needs and the professional's desire for creative freedom are compatible, he asserts. Case histories are cited in which the research professional's suggestions for work in areas not previously considered are applauded by management men responsible for their company's research and development activities.

Copies of the statement are available from Publications Office, Battelle Memorial Institute, 505 King Avenue, Columbus 1, Ohio.

DRAGLINE-CLAMSHELL

A Model 210-B diesel-electric dragline and clamshell has been added to the Bucyrus-Erie line of heavy-duty crawler excavators. The South Milwaukee, Wisconsin, manufacturer of construction and mining equipment says the new machine, with boom lengths of 100, 120, and 140 ft., can handle buckets up to 10 cu. yd. Designed for high production and low maintenance, a key feature of the 210-B is the elimination of friction clutches for all cyclic functions. Hoist and drag or holding and closing motions are regulated by a static-type control of independent electric eddy current clutches, which are liquid cooled by a radiator system. The swing motion is controlled by a variable Ward Leonard system.

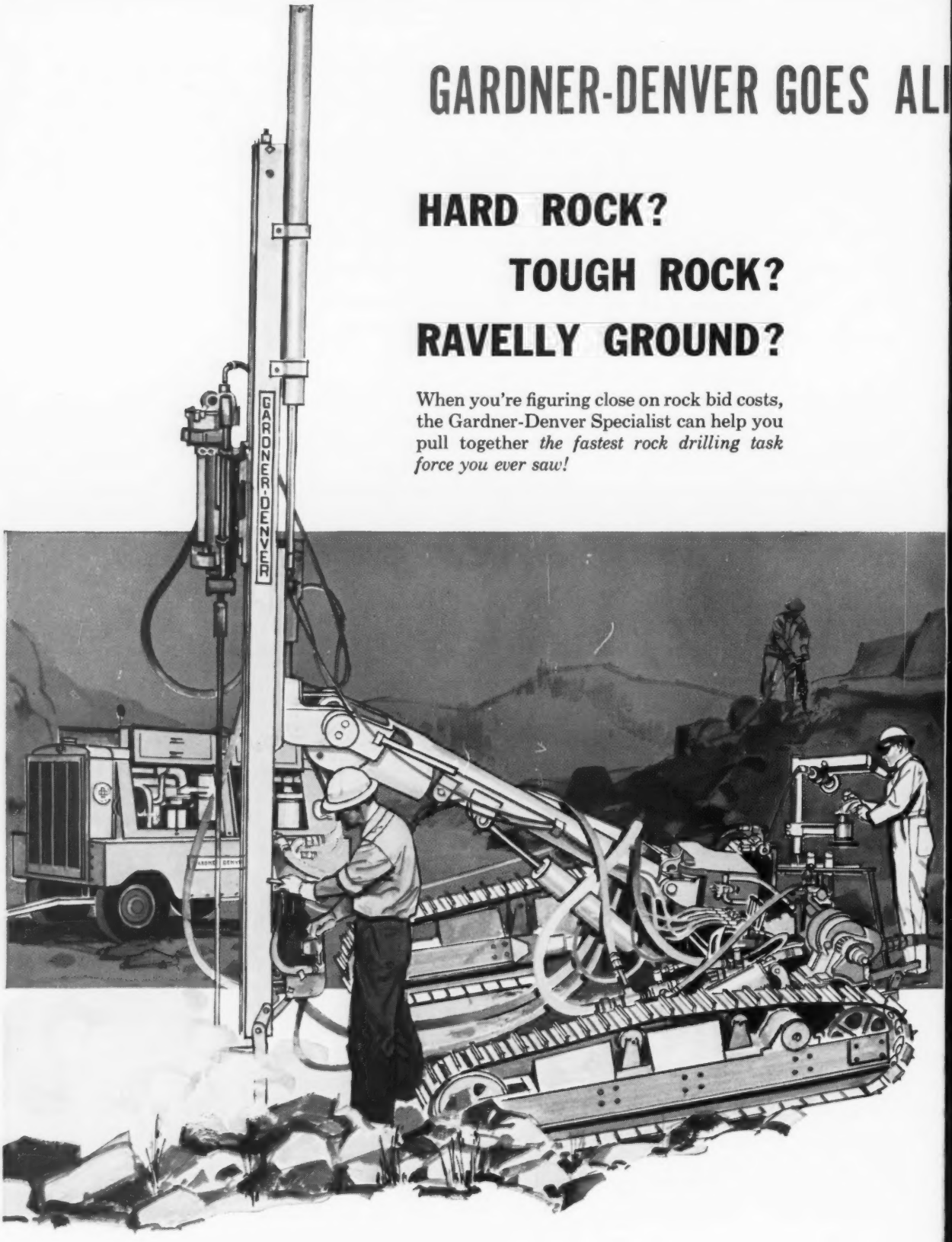
Three sets of crawlers are available—standard, intermediate, and long-wide for soft ground conditions.

For complete 210-B information, write Sales Promotion Division, Bucyrus-Erie Co., South Milwaukee, Wisconsin.

GARDNER-DENVER GOES ALI

HARD ROCK?
TOUGH ROCK?
RAVELLY GROUND?

When you're figuring close on rock bid costs, the Gardner-Denver Specialist can help you pull together *the fastest rock drilling task force you ever saw!*



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- Heavy-Duty HT143 Crawler Drill with 5½" percussion drill for big bore blast hole drilling.
- "Air Trac"® Crawler Drills that outmaneuver anything else on the market.
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- Carburized Sectional Rod and Couplings with the new "HI-LEED"® thread that joins sections firmly for greater impact transmission . . . yet always uncouples quickly. Known for long service.
- Carbide Insert Rock Bits that match the extra life and efficiency of Gardner-Denver steel.
- Pneumatic Bit Grinders that keep your bits sharp right at the rig.
- Air Line Oilers to keep your rock drills and tools properly lubricated for longer life.
- Hand-Held Drills for trimming and secondary blasting. A size and weight for every type of rock.
- And for low-cost air power—the new Gardner-Denver Rota-Screw Portables provide immediate, steady compressed air in any weather or climate. They'll slash your maintenance costs because there are no blades or other moving parts in the compression chamber.

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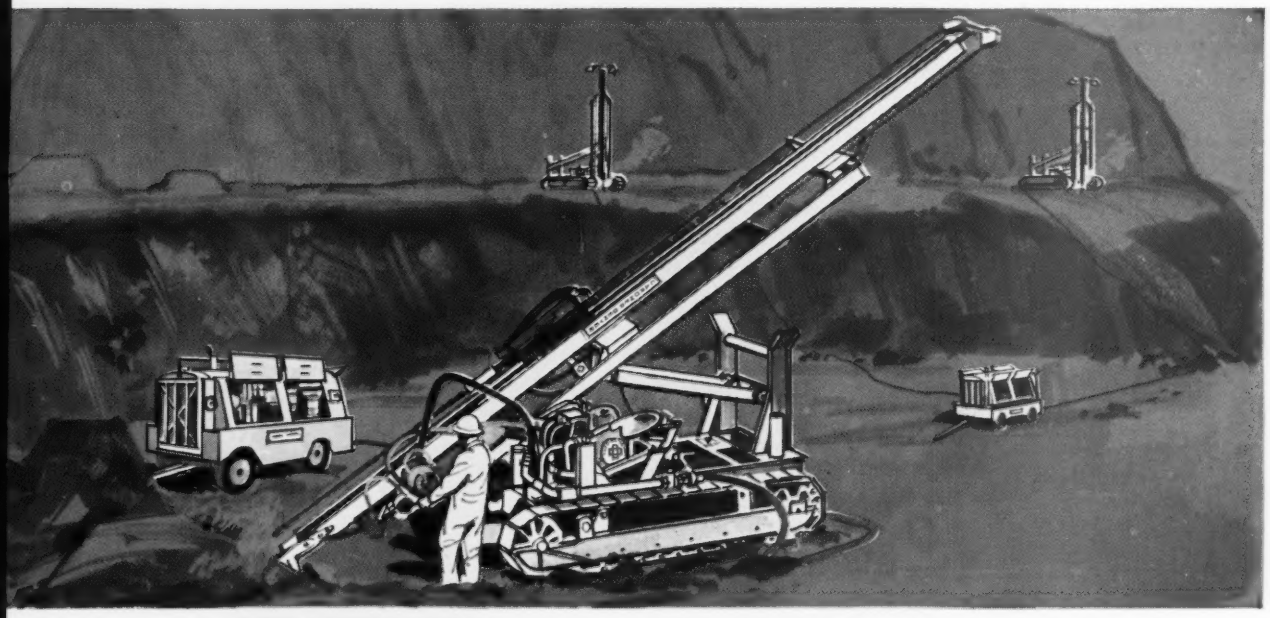

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EXPLORATION

PORTADRILL *Field Report*

Owner: J. R. Simplot Co., Pocatello, Idaho

Drill: Portadrill "BHD" Air Operated

Location: Phosphate (P_2O_5) Strip Mine

Application: Defining ore bodies; drilling blast holes and mineral sampling for ore grade control

This Portadrill BHD, operating with a driller and one helper, averages 290′ of 4¾″ diameter hole per shift with average hole depths of 90′ in shale, limestone, silt stone and chert formations. Penetration rate averages 38.7 ft per hour. Maximum hole production on any one shift has run as high as 400′.

In addition to all drilling operations, the two man crew logs each hole and take 5′ samples which they package and label. Ore grade control is maintained within 0.3%.

FOUR PORTADRILLS SPEED BLASTING AND EXPLORATION ACTIVITIES

The BHD is one of four Portadrills owned and operated by the Simplot organization. Three "air blast" BHD's are located on various Idaho mines for blast hole work, exploration and mineral sampling. The fourth unit, a Portadrill Model 10TE 3-way drill (utilizing conventional bits with air or water or down-the-hole rotary tools for hard rock) is operated by Simplot's Exploration Division in ALL types of rotary drilling throughout the Western States.

Here is another example of greater efficiency provided by Portadrills — truck, tractor or trailer mounted units which may be "customized" to do specific jobs. Inquiries concerning Portadrills for blast and exploratory hole applications to 2,000′ depths or 60″ diameters are welcomed. Field engineering services are available throughout the world. Address:

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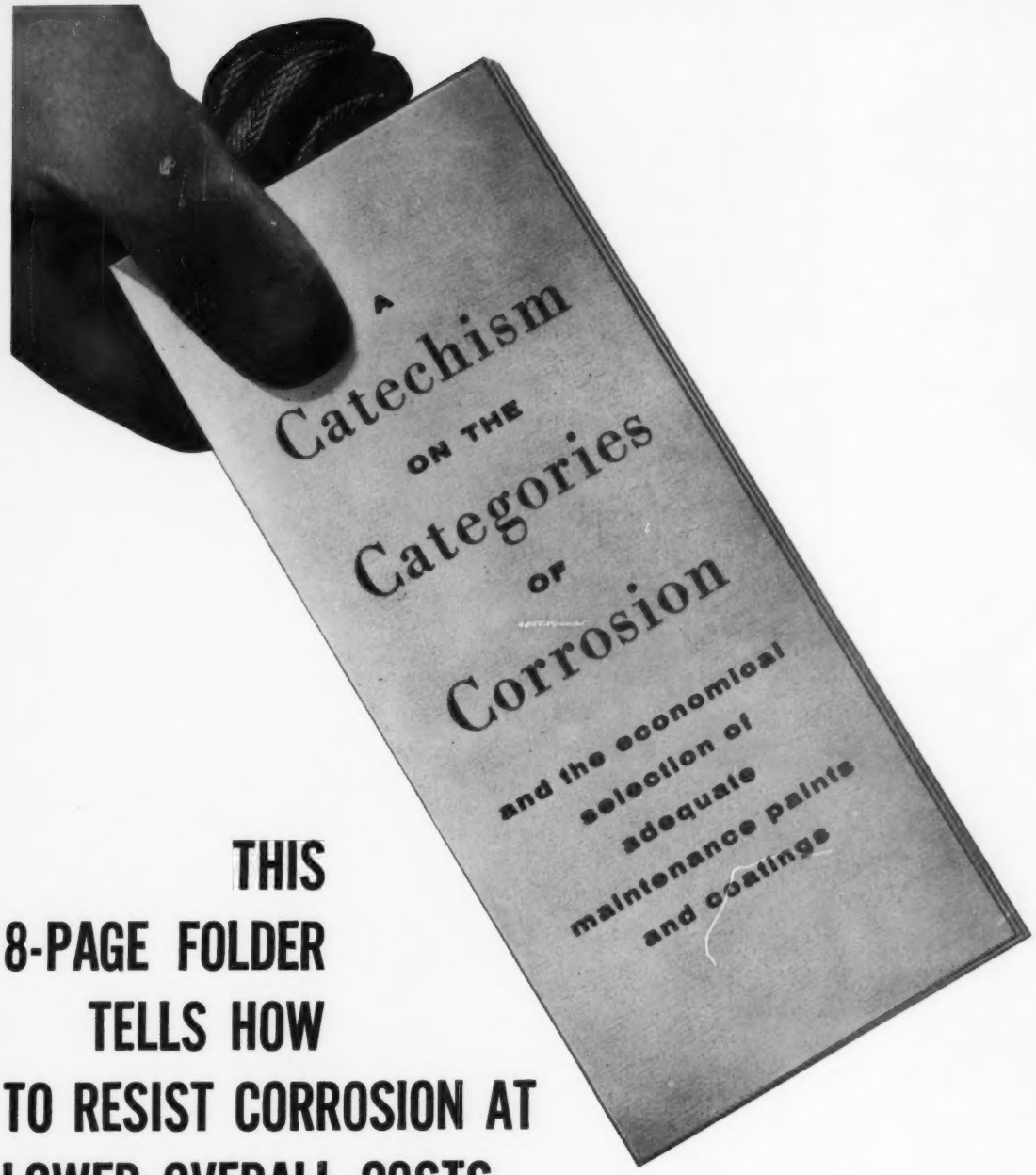

THIS 8-PAGE FOLDER TELLS HOW TO RESIST CORROSION AT LOWER OVERALL COSTS

If you have anything to do with maintenance of equipment or structure, or with the costs that result therefrom, this folder may be extremely useful to you. It gives a rational basis for paint and painting specifications, and tells how all surface and area exposures can be classified into the Four Categories of Corrosion.

As in all other phases of engineering, both underdesign and overdesign of maintenance painting carry economic penalties. Either one will show up sooner or later on the overall cost sheets. Although Hercules does not make any finished paints or coatings, we have had over twenty-five years' practical experience with Parlon® chlorinated rubber, a key material for corrosion-resistant and high-performance maintenance paints.

This booklet has been written with this background of experience. Write for your copy.

Polymers Department

HERCULES POWDER COMPANY

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Hercules Tower, 910 Market Street, Wilmington 99, Delaware

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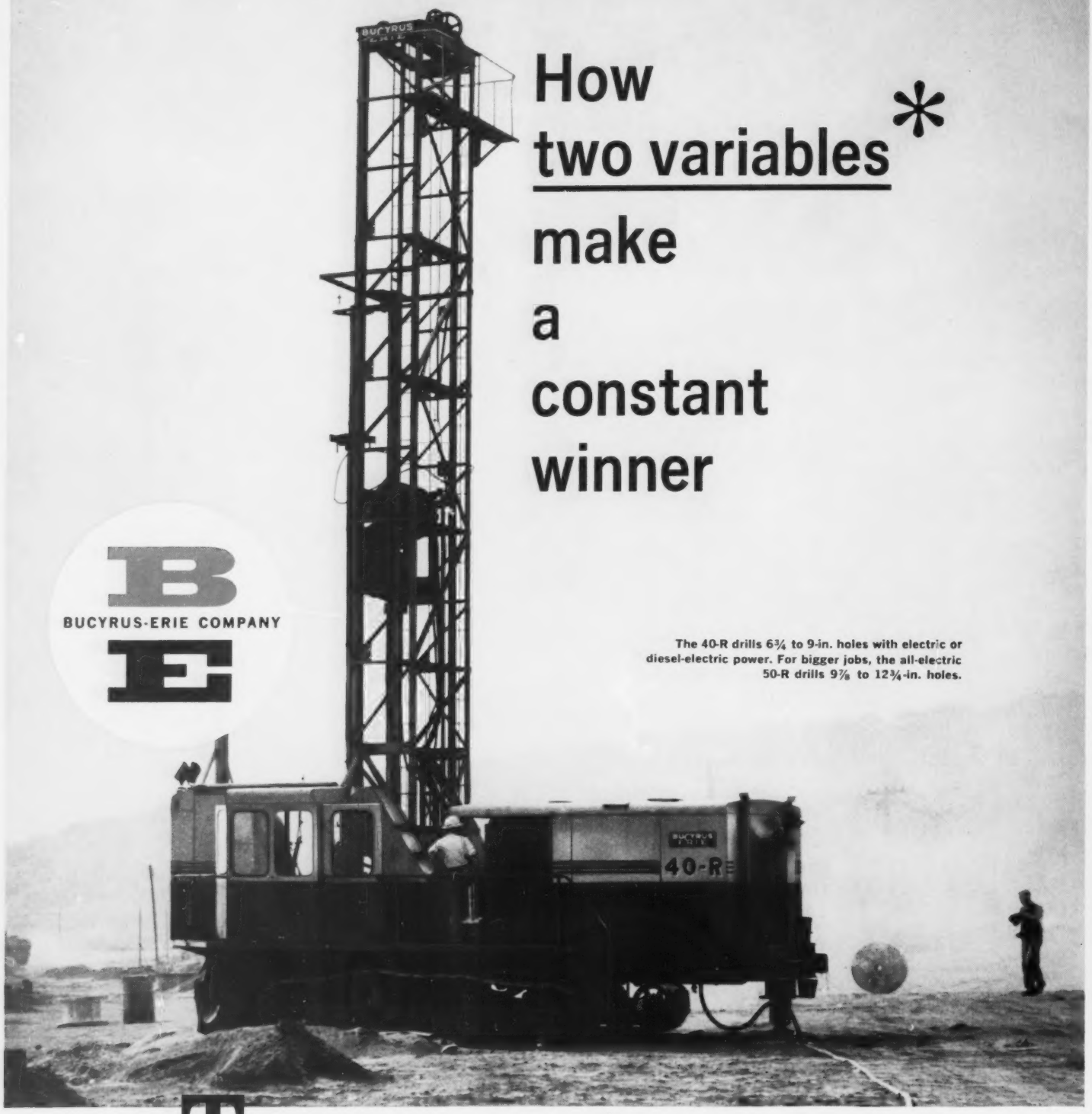
How two variables* make a constant winner

BUCYRUS-ERIE COMPANY



The 40-R drills 6¾ to 9-in. holes with electric or diesel-electric power. For bigger jobs, the all-electric 50-R drills 9⅞ to 12¼-in. holes.

The Bucyrus-Erie 40-R has been constantly setting new footage records. Here are two important reasons:

*VARIABLE DRILLING SPEED — Ward Leonard variable voltage control lets you choose the correct rotary speed for a given formation and adapts instantly to changes without stopping the drilling operation.

*VARIABLE PULLDOWN PRESSURE — Hydraulic down pressure works in any desired combination with rotary speed. Result: Record-breaking, bit-saving production under all conditions.

Let your Bucyrus-Erie sales representative tell you more about the tough, fast-working 40-R, or write Bucyrus-Erie Company, Drill Division, South Milwaukee, Wisconsin.

2561

Hercules has more than one hundred technically trained sales and service representatives strategically located throughout all major explosives-consuming areas. These Hercules men are ever ready to place their specialized talents at your service in helping to solve your blasting problems.

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What makes the best drilling team? Is it maximum footage? Low fuel consumption? Lowest maintenance? It's all these and more.

Look at the Rock Master drill, for example. It has mobility to get around the roughest ground—to move the air compressor; maneuverability to spot the drill where you want it . . . quickly . . . accurately; stability to hold mast alignment for fast, accurate drilling; simplicity to provide long, trouble-free service; plus the WD-45 Heavy Duty 4½" Drifter for fast drilling.

In one side-by-side comparison the Rock Master put down 3.1 holes per hour. The competitive crawler drill put down 2.7 holes per hour. There's other proof, too, that the Worthington Rock Master can outperform any competitive crawler drill.

What about operation? It has easier, safer controls; a more powerful feed motor for faster steel changes; and an automatic line oiler that reduces maintenance.

What about air consumption? The air consumption of the Rock Master is so low that you can easily operate two units from one 900′ compressor, as is being done on the job above. Or, one Rock Master can operate from a 600′ compressor with plenty of air to spare for boulder popping, running a bit sharpener. a dust ejector or even a blow pipe for cleaning holes!

For the large volume air supply, you can't make a better buy or rental than the Blue Brute 900′ Compressor. It's efficient —less fuel consumed at the end of the day. And it has all the ease-of-operation and safety features you'll ever possibly need.

To get more information on the Rock Master or on the Blue Brute 900′ compressor, call your Worthington rotary compressor distributor listed in the Yellow Pages. Ask him for a quotation, so you can see the Blue Brute drilling team in a truly competitive light. Or write Worthington Corporation, Dept. 61-1, Holyoke, Mass. In Canada, Worthington (Canada) Ltd., Brantford, Ontario.

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